PHILIPS

Digital multimeter

PM2422A

9447 024 221..

9499 470 08802

740901/A5/A6

PHILIPS

PHILIPS

Manual

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740901/A5/A6

IMPORTANT

In correspondence concerning this instrument please quote the type number and the serial number as given on the type plate at the rear of the instrument.

WICHTIG

Bei einem Schriftverkerhr über dieses Gerät bitte immer die Typennummer und die Seriennummer angeben, die auf dem Typenschild an der Rückseite des Gerätes stehen.

ATTENTION

Veuillez indiquer le numéro de type et le numéro de série tels que portés sur la plaque du constructeur à l'arrière de l'instrument, dans toute correspondance relative à cet appareil.

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GENERAL

I. INTRODUCTION

The Philips digital multimeter PM 2422 A is an accurate 3+1 digit instrument with a maximum reading of 1999 to measure:

- DC and AC voltages of 100 µV ... 1000 V (600 V AC,) 5 ranges
- DC and AC currents of 100 nA ... 2 A, 5 ranges
- Resistances of 0.1 Ω ... 20 MΩ, 6 ranges
- DC high voltages up to 30 kV with the EHT probe PM 9246
- UHF voltages with UHF probe PM 9200 up to 800 MHz.

  For frequencies above 30 MHz it is advisable to use T-connector PM 9250 in conjunction with this probe.
- DC and AC currents up to 31.6 A with shunt PM 9244
- AC currents up to 100 A with current transformer PM 9245

Operation of the instrument is easy.
Selection of the measuring ranges is effected by a rotary switch, and AC and DC selection by push-buttons.
The decimal point is set automatically by switching the ranges.
The polarity of direct voltages and currents is indicated automatically.
Only the -sign is displayed.
The instrument is protected against overloads on all ranges up to at least 250 V.
This efficiently designed instrument can be employed for all applications in modern electronics.

II. TECHNICAL DATA

Properties expressed in numerical values with tolerances are guaranteed by the manufacturer.
Numerical values without tolerances are given for general information and represent the properties of an average instrument.
The data below are applicable at $23^{\circ}C \pm 1^{\circ}C$ unless otherwise stated.

A. MEASURING RANGES

1. Direct voltages

Measuring range	0.1 mV ... 1000 V 5 ranges up to 200 mV, 2 V, 20 V, 200 V and 1 kV

Resolution	100 µV
Accuracy	± 0.1% of range and ± 0.1% of reading
Temperature coefficient	± 1 digit / 5°C
Input resistance	10 MΩ ± 0.2%
Input capacity	< 100 pF
Series mode rejection	> 66 dB at 50 Hz and 60 Hz
Common mode rejection	> 120 dB at DC, 50 Hz and 60 Hz

2. Alternating voltages

Measuring range	0.1 mV ... 600 V 5 ranges up to 200 mV, 2 V, 20 V, 200 V and 600 V
Maximum resolution	100 µV
Input impedance	10 MΩ ± 0.2% // max. 100 pF
Accuracy	± 0.2% of range and ± 0.2% of reading } at a frequency of 1 kHz ± 0.3% of range and ± 0.3% of reading } at a frequency of 30 Hz ...20 kHz ± 0.5% of range and ± 0.5% of reading } at a frequency of 20 kHz ... 25 kHz
Temperature coefficient	± 1 digit / 5°C
Frequency range	30 Hz ... 25 kHz
Max. input voltage	600 V
Max. frequency on 600 V range	1 kHz

3. Direct currents

Measuring range	100 nA ... 2 A 5 ranges up to 200 µA, 2 mA, 20 mA, 200 mA and 2 A
Maximum resolution	100 nA
Accuracy	± 0.3% of range and ± 0.3% of reading
Temperature coefficient	± 1 digit / 4°C
Voltage loss	< 250 mV for currents ≤ 200 mA < 600 mV for 2 A

4. Alternating currents

Measuring range	100 nA ... 2 A 5 ranges up to 200 µA, 2 mA, 20 mA, 200 mA and 2 A
Maximum resolution	100 nA
Accuracy	± 0.4% of range and ± 0.4% of reading
Frequency range	30 Hz ... 1 kHz
Temperature coefficient	± 1 digit / 4°C
Voltage loss	< 250 mV for current ≤ 200 mA < 600 mV for 2 A

5. Resistances

Measuring range	0.1Ω ... 20 MΩ 6 ranges up to 200 Ω, 2 kΩ, 200 kΩ, 2 MΩ and 20 MΩ
Maximum resolution	0.1 Ω
Accuracy	± 0.2% of range and ± 0.2% of reading } for ranges < 200 kΩ ± 0.2% of range and ± 0.5% of reading } for the 2 MΩ and 20 MΩ ranges
Temperature coefficient	± 1 digit / 3°C for ranges ≤ 200 kΩ ± 1 digit / 2°C for the 2 MΩ and 20 MΩ ranges
Measuring current	1 mA for the 200 Ω and 2 kΩ ranges 10 µA for the 20 kΩ and 200 kΩ ranges 100 nA for the 2 MΩ and 20 MΩ ranges
Max. voltage with open input	< 2.7 V for the 200 Ω, 20 kΩ, and 2 MΩ ranges < 12 V for the 2 kΩ, 200 kΩ and 20 MΩ ranges
Semi-conductors	Can be tested forwards on the 2 kΩ range and reverse on the 2 MΩ and 20 MΩ ranges

B. GENERAL DATA

1. Display

Number of digits	3 + 1
Max. display	1999
Polarity	Automatic display of "-" sign No indication for + DC, AC and Ohm
Overrange	The digit of the hundreds displays 0, the others are blanked.
Decimal point	Set automatically by range selector

2. Analog to digital conversion

Conversion system	Delta pulse modulation system ⁎
Sampling rate	2 times per second, memory keeps the reading displayed during the measuring time
Display control	Serial, Scan frequency 512 Hz

3. Input

Measuring input	Floating
Range selection	Manual
Max. common mode signal	500 V d.c. 350 V a.c., 50 Hz
Capacity "0" - ⊥	1.8 nF
Maximum voltage between V-R and ⊥	1000 V d.c. or 1000 V r.m.s.

4. Temperature range

Ambient temperature	0 ... 45°C
Zero point drift	± 1 digit / 4°C

5. Protection

Max. permissible voltages

Range	Value
Ranges ≤ 2 V DC and AC	350 V d.c.;300 V a.c.(50 Hz)
Ranges > 2 V AC	500 V d.c.;600 V a.c.
Ranges > 2 V DC	1.2 kV d.c.; 600 V a.c.

The voltage ranges are protected for overloads up to 3 kV supplied by high ohmic sources

Current ranges: 6 A fuse and power diodes for protection of the shunts. Max. permissible voltage 250 V d.c. or a.c.

⁎ Philips patent

Resistance ranges	Protected against 250 V d.c. or a.c. (50 Hz) For ranges $\leq$ 2 kΩ above 30 V a fuse (125 mA) will blow

6. Power supply

Mains voltage	110 V or 220 V $\pm$ 15% Additional adaption by 18 V is possible
Frequency	40 - 60 Hz
Power consumption	30 VA

C. MECHANICAL DATA

Dimensions	Height: 145 mm Width : 236 mm Depth : 298 mm
Weight	about 3.5 kg

III. ACCESSORIES

A. SUPPLIED AS PART OF THE EQUIPMENT

Set of measuring leads with test pins PM 9260
Interconnection strip between terminals "0" and ⊥

B. OPTIONALLY AVAILABLE

EHT probe PM 9246 (fig. 1, page 12)

The HT probe PM 9246 is suitable for measuring direct voltages up to 30 kV.
The PM 9246 may be used for measuring instruments with an input impedance of 100 MΩ, 10 MΩ or 1.2 MΩ (selectable).

TECHNICAL DATA

Maximum voltage	30 kV
Attenuation	1000 x
Input impedance	600 MΩ ± 5%
Accuracy	± 3% for instruments input impedance of 10 MΩ and 100 MΩ ± 5% for instruments input impedance of 1.2 MΩ

Note:
Pay attention to safe earth connections

UHF probe 9200 (fig. 2, page 42)

The UHF probe PM 9200 is suitable for measuring alternating voltages between 10 mV and 16 V.

Frequency range	100 kHz ... 800 MHz
Frequency response	100 kHz ... 1 MHz ± 10% 1 MHz .. 300 MHz ± 5% 300 MHz .. 800 MHz ± 10%
Input impedance	1 MHz .. 110 kΩ 10 MHz .. 80 kΩ 50 MHz .. 25 kΩ
Input capacitance	2 pF
Max. permissible voltage on the probe	450 V d.c.

At frequencies above 30 MHz these tolerances apply only if T-connector PM 9250 is used.

UHF T-connector PM 9250 (fig. 3, page 42)

Impedance	50 Ω
Frequency response	0.1 ... 1000 MHz
Standing wave ratio	0.1 ... 800 MHz : 1.1 800 ... 1000 MHz : 1.2

Current transformer PM 9245 (fig. 4, page 42)

With this transformer it is possible to measure alternating currents over 10 A up to 100 A.

Transfer factor	1000 x (100 A = 100 mA)
Transfer error	± 3%
Frequency range	45 Hz ... 1 kHz
Secundary voltage loss	< 200 mV
Max. voltage with respect to earth	400 V a.c.
Max. air-gap	0.05 mm

Before measuring connect the current transformer to the instrument.

Prevent polution of the core-parts.

Shunt PM 9244 (fig. 5, page 42)

With this shunt it is possible to measure d.c. and a.c. (max. 1 kHz) currents up to 31.6 A.

Current range	10 A and 31.6 A
Output voltage	100 mV and 31.6 mV
Accuracy	100 mV: ± 1% 31.6 mV : ± 2%
Dissipation	max. 3.16 W
Dimensions	Height : 55 mm Width : 140 mm Depth : 65 mm

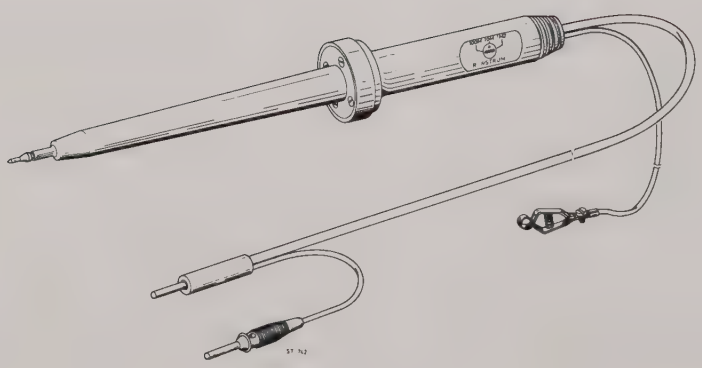


Fig. 1.

IV. PRINCIPLE OF OPERATION (Fig. 8)

A. INPUT CIRCUIT

The purpose of the input circuit is to supply a direct voltage of 2 V to the ADC input, at end of range values.

The analog sections translates all input signals viz. d.c. and a.c. voltages, d.c. and a.c. currents and resistances to this signal of 2 V.
For the d.c. and a.c. voltages the same divider is used.

The attenuated signal is supplied to an 1 x or 10 x amplifier with an output of 2 V d.c. or 2 $V_{r.m.s.}$
In the case of a.c. measurements the output signal of the amplifier is supplied to an AC/DC converter, which is out of circuit in the case of d.c. measurements.

Currents supplied to input I are converted into voltages by shunts.

These voltages are also supplied to the 1 x or 10 x amplifier and then directly, or in the case of a.c. currents via the AD/DC converter, supplied to the ADC.

For resistance measurements, a constant current is passed through the unknown resistance.

The following currents are used in the different ranges:

Ranges	Current	Measuring voltage (at end of range)
200 Ω	1 mA	200 mV
2 kΩ	1 mA	2 V
20 kΩ	10 µA	200 mV
200 kΩ	10 µA	2 V
2 MΩ	100 nA	200 mV
20 MΩ	100 nA	2 V

The measuring voltage across the unknown resistance is supplied to the ADC via the 1 x or 10 x amplifier.

B. DIGITAL SECTION

The analog to digital converter of the PM 2422 A is based on the delta-pulse modulation principle. This integrating system ensure good linearity and series mode rejection. Furthermore the circuit contains a minimum of critical elements, only the accuracy of the reference voltage is important for the accuracy of the ADC.

The basic circuit of the ADC is shown in Fig. 7. The operation is as follows:

With a comparator the input voltage V_x is compared with voltage V_c

The output of the comparator controls switch S via flip-flop in such a way that the positive reference voltage ($+V_{REF}$) is connected to R1 if $V_c < V_x$ or the negative reference ($-V_{REF}$) if $V_c > V_x$.

Suppose V_x is positive with respect to V_c and switch S to position $+V_{REF}$.
This results in charging the capacitor so that V increases until it becomes larger than V_x.
At the first clock pulse after V_c has become larger than V_x, flip-flopFF is set; switch S is set to position $-V_{REF}$. Capacitor C1 will be discharged until V_c becomes smaller than V_x. Then switch S is set again to the starting position (S in position $+V_{REF}$) at the next clock pulse.

Due to this compensation method the average value of V_c will be equal to V_x. If V_x has a constant value (a.d.c. level) the average charge of capacitor C1 must be also constant. This means, that the charge supplied (Q_c) is equal to the charge drained off (Q_d) when integrated over a longer period (measuring time t_m).

Charge supplied: $$Q_c = \frac{+V_{REF} - V_c}{R} \cdot t_c$$

Charge drained: $$Q_d = \frac{V_c - (-V_{REF})}{R} t_d$$

thus: $$V_c = V_x = \frac{t_c - t_d}{t_c + t_d} \cdot V_{REF} \text{ or } V_x = \left(\frac{t_c}{t_c + t_d} - \frac{t_d}{t_c + t_d}\right) V_{REF}.$$

in which t_c = sum of the charging times, t_d = sum of the draining times during time t_m ($+V_{REF}$ and $-V_{REF}$ have the same absolute value).

By counting the number of clock pulses during the charging time (t_c) and subtracting the clock pulses during the draining time (t_d) this results in a number of clock pulses which corresponds to the input voltage.

Assume: N = total number of clock pulses during t_m
T = period time of clock pulse

then t_m = measuring time = $NT = t_c + t_d$,

If during t_c, n clock pulses are used, then during t_d N-n pulses are used, so that V_x becomes

$$V_x = \frac{nT - (NT - nT)}{NT} V_{REF} = \frac{2n - N}{N} V_{REF} \cdot$$

If 2 n-N = n' = the number of pulses to be counted, then:

$$n' = V_x \frac{N}{V_{REF}}$$

N is a fixed number of pulses determined by a timer and amounts to 2046. When using a reference voltage of 2.046 V the formula becomes

$$n' = 1000\ V_x \qquad (V_x \text{ in volts})$$

(In PM 2422 A capacitor C1 is connected between the inputs of the comparator to obtain a better series mode rejection).

The counting of pulses is realised in an up-down counter which is included in a MOS integrated circuit. This circuit contains, moreover:

- An input flip-flop (FF, described before)
- Two analog switches (S) to switch the positive and negative reference voltage
- A polarity detector
- A timer to control the measuring time
- A clock oscillator
- A pulse output circuit which controls the 4-decade counter.

The latter circuit counts the pulses supplied by the ADC.

The number of counted pulses will be transferred to a memory after which the counter will be reset to zero by a reset pulse from the ADC.
A new measuring cycle can start now.
A multiplexer connects alternately each decade of the memory to the decoder-driver, simultaneously a pulse arises to drive the anode switch of the corresponding indicator tube.
Via the decoder-driver the decoded number will be transferred to one of the 4 indicator tubes, the cathodes of which are switched in parallel.
Only that indicator, the anode switch of which is closed, will light up.
As the switching speed is 512 times per second it seems that all indicators light at the same time.

V. INSTALLATION

A. MAINS SUPPLY

Before the instrument is connected to the mains, check that the instrument is set to the local voltage.

If necessary, connect the transformer windings as shown in Fig. 9.

The instrument is set to 220 V in the factory.

B. FUSE

Make sure that only fuses with the required current rating and of the specified type are used. The use of repaired fuses and the short-circuiting of fuse holders is prohibited.
The rating of the mains fuse mounted inside on the rear plate (fig. 32, page 101) should be:

- for 110 V : 250 mA, delayed action
- for 220 V : 140 mA, delayed action

C. EARTHING

The instrument should be connected to a protective earth in accordance with the local safety regulation. This can be effected via the 3-core means lead. The mains plug should only be inserted in a socket outlet provided with a protective earth contact, the protective action of which is not cancelled by the use of an extension card or device without protective conductor.

VI. OPERATION

A. SWITCHING ON (fig. 10)

The instrument is ready for use after connection to the mains and earthing. It is switched on by means of mains switch POWER ON (SK3)
Then the display tubes light up.
A warming-up time of approximately 30 min. should be observed to obtain full accuracy.

B. ELECTRICAL ZERO SETTING

- Switch on the instrument and allow to warm up for approximately 30 min.
- Interconnect terminals "0" (BU2) and "V-R" (BU3)
- Press push-button DC (SK2/1)
- Set range selector (SK1) to position 200 mV
- Adjust the reading to 00.0 by means of potentiometer "ZERO" (screwdriver adjustment at the rear of the instrument).
- If the indicator "-" blinks it is an indication that the zero setting has been effected correctly.

C. CALIBRATION

Calibration of this instrument may only be carried out if a DC standard with an accuracy of at least ± 0.04% (preferably ± 0.02%) is available.
For calibration reference is made to chapter XI sub-point D.1.

D. MEASURING

1. Direct and alternating voltages

- Select measuring mode DC-R or AC
- Select the correct measuring range with range selector SK1
- Connect the test voltage to terminals "0" (BU2) and V-R (BU3)

Notes:

- For floating measurements, remove interconnection strip between "0" (BU2) and ⏚ (BU1).
- The capacitance between terminals "0" and ⏚ is approximately 1.8 nF.
- For d.c. voltages the polarity indicator indicates the polarity on terminal V-R with respect to terminal "0". Only the "-" sign will be displayed.
- Maximum permissible voltage between terminal "0" and chassis ⏚ is 500 V d.c. or 350 V a.c. 50 Hz
- Maximum permissible voltage between terminal V-R and chassis ⏚ is 1000 V d.c. or 1000 V r.m.s.
- Maximum permissible voltage:

Range	Measuring mode DC	Measuring mode AC
200 mV 2 V	350 V d.c.; 300 V a.c. (50 Hz)	350 V d.c.;300 V a.c.(50 Hz)
20 V 200 V 1000 V	1.2 kV d.c.; 600 V a.c. (50 Hz)	500 V d.c.;600 V a.c.(50 Hz)

2. EHT voltages up to 30 kV with probe PM 9246

- Select measuring mode DC-R
- Connect the probe terminals "0" and V-R (terminals "0" and ⊥ should be interconnected by the interconnection strip)
- Connect the earthing clip of the probe to a proper earth
- Select the 10 MΩ range on the probe
- With the range selector the following ranges are possible.

Range selector to position	HT range
20 V	2 kV max.
200 V	20 kV max.
1000 V	30 kV max. (see note)

Notes:

- Maximum permissible d.c. voltage 30 kV (range end is 100 kV)
- The position of the decimal point should be observed.

3. UHF voltages (with probe PM 9200 and T-connector PM 9250)

- Select measuring mode DC-R
- Connect the probe to terminals "0" and V-R, with the earthing pin to "0" (terminals "0" and ⊥ should be interconnected)
- Set measuring range selector to the desired position.

Notes:

- The maximum permissible voltage on the probe is 16 $V_{r.m.s.}$
- The correction factor on the calibration curve of the probe should be taken into account.

4. Direct and alternating currents

- Select measuring mode DC-R or AC
- Select the correct measuring range with selector SK1
- Connect the current source to be measured to terminals "0" and I (BU4)

Notes:

- The polarity indicator shows the polarity at terminal I with respect to terminal "0". Only the "-" sign will be displayed.
- Maximum permissible voltage on the current terminals in all ranges 250 V a.c. or d.c.
- The shunts are protected with a 6 A fuse (see chapter VIII sub-point B).

5. DC and AC (max. 1 kHz) currents up to 31.6 A with DC shunt PM 9244

- Select measuring mode DC-R or AC
- Connect the output sockets + and - of shunt PM 9244 to terminals V-R and "0" (BU3 and BU2)
- Set the range selector to position 200 mV
- Connect the current source to terminals - and 10 A or 31.6 A dependent on the current to be measured.
- By means of switch SK1 (Fig. 5) the output voltage of shunt PM 9244 can be switched-over from 100 mV to 31.6 mV.

6. AC currents up to 100 A with current transformer PM 9245

- Select measuring mode AC
- Connect the terminals of transformer PM 9245 to terminals "0" and I
- Set the range selector to position 200 mA
- Pass the current-carrying conductor through the opening of the transformer.
- Maximum permissible alternating current 100 A.
- Frequency range 45 Hz - 1 kHz.

7. Resistors

- Select measuring mode DC-R
- Connect the unknown resistor to terminals "0" and V-R
- Select the correct measuring range.

Notes:

- The measuring current is : 1 mA for the 200 Ω and 2 kΩ ranges,
  10 µA for the 20 kΩ and 200 kΩ ranges and
  100 nA for the 2 MΩ and 20 MΩ ranges.
- For measuring resistors measuring clip PM 9261 can be used.
- Semi-conductors can be measured in forward direction of range 2 kΩ. The display shows the diode voltage in forward direction of 1 mA. Terminal "V-R" (BU3) is positive with respect to terminal "0" (BU2).

I. EINLEITUNG

Das Philips Digital-Multimeter PM 2422 A ist ein genaues Messgerät mit 3+1 Ziffer mit einer maximalen Anzeige von 1999 zur Messung von:

- Gleich- und Wechselspannungen von 100 µV ... 1000 V (Wechselspannungen: 600 V) in 5 Teilbereichen
- Gleich- und Wechselströmen von 100 nA ... 2 A in 5 Teilbereichen
- Widerstände von 0,1 Ω ... 20 MΩ in 6 Teilbereichen
- Gleichspannungen bis 30 kV mit dem Hochspannungs-Messkopf PM 9246
- UHF-Spannungen bis 800 MHz mit den UHF-Messkopf PM 9200

  Es wird empfohlen, für Frequenzen über 30 MHz das T-Stück PM 9250 zusammen mit diesem Messkopf zu verwenden.
- Gleich- und Wechselströme bis 31,6 A mit dem Shunt PM 9244
- Wechselströme bis 100 A mit dem Stromwandler PM 9245.

Die Bedienung des Gerätes ist einfach.
Die Messbereiche werden mit einem Drehschalter eingestellt und die Wahl von Gleich- oder Wechselspannungen erfolgt mit Drucktasten.
Die Dezimalstellenanzeige wird beim Umschalten der Bereiche automatisch mit umgeschaltet.
Die Polarität von Gleichspannungen und Gleichströmen wird automatisch angegeben.
Nur das Minus-zeichen wird angezeigt.
Das Gerät ist in allen Bereichen bis mindestens 250 V überlastungssicher.
Das Gerät ist für alle Arbeiten in der modernen Elektronik geeignet.

II. TECHNISCHE DATEN

Zahlwerte mit Toleranzangabe werden vom Hersteller garantiert. Zahlwerte ohne Toleranzangabe sind nur zur allgemeinen Information und geben die Eigenschaften eines durchschnittlichen Gerätes an. Die folgenden Daten gelten, sofern nicht anders angegeben, bei einer Temperatur von 23°C ± 1°C.

A. MESSBEREICHE

1. Gleichspannungen

Messbereich	0,1 mV ... 100 5 Bereiche: 200 mV, 2 V, 20 V, 200 V und 1 kV

Auflösung	100 µV
Fehlergrenze	± 0,1% vom Endwert ± 0,1% vom Anzeigewert
Temperaturkoeffizient	+ 1 Ziffer / 5°C
Eingangswiderstand	10 MΩ ± 0,2%
Eingangskapazität	< 100 pF
Serienstörspannungsunterdrückung	> 66 dB bei 50 und 60 Hz
Gleichtaktstörspannungs-unterdrückung	> 120 dB bei Gleichspannungen, 50 und 60 Hz

2. Wechselspannungen

Messbereich	0,1 mV ... 600 V 5 Bereiche: 200 mV, 2 V, 20 V, 200 V und 600 V
Auflösung	100 µV
Eingangsimpedanz	10 MΩ ± 0,2% / max. 100 pF
Fehlergrenze	± 0,2% vom Bereichsendwert ± 0,2% vom Anzeigewert } bei 1 kHz ± 0,3% vom Bereichsendwert ± 0,3% vom Anzeigewert } für Frequenzen von 30 Hz ... 20 Hz ± 0,5% vom Bereichsendwert ± 0,5% vom Anzeigewert } für Frequenzen von 20 kHz ... 25 kHz
Temperaturkoeffizient	± 1 Ziffer / 5°C
Frequenzbereich	30 ... 25 kHz
Maximale Eingangsspannung	600 V
Maximale Frequenz im 600-V-Bereich	1 kHz

3. Gleichströme

Messbereich	100 nA ... 2 A 5 Bereiche: 200 µA, 2 mA, 20 mA, 200 mA und 2 A
Auflösung	100 nA
Fehlergrenze	± 0,3% vom Bereichsendwert ± 0,3% vom Anzeigewert
Temperaturkoeffizient	± 1 Ziffer / 4°C
Spannungsabfall	< 250 mV bei Strömen ≤ 200 mA < 600 mV bei 2 A

4. Wechselströme

Messbereich	100 nA ... 2 A 5 Bereiche: 200 µA, 2 mA, 20 mA, 200 mA und 2 A
Auflösung	100 nA
Fehlergrenze	± 0,4% vom Bereichsendwert ± 0,4% vom Anzeigewert
Frequenzbereich	30 Hz ... 1 kHz
Temperaturkoeffizient	± 1 Ziffer / 4°C
Spannungsabfall	< 250 mV bei Strömen ≤ 200 mA < 600 mV bei 2 A

5. Widerstände

Messbereich	0,1 Ω ... 20 MΩ 5 Bereiche: 200 Ω, 2 kΩ, 20 kΩ, 200 kΩ, 2 MΩ und 20 MΩ
Auflösung	0,1 Ω
Fehlergrenze	± 0,2% vom Bereichsendwert ± 0,2% vom Anzeigewert } für Bereiche < 200 kΩ ± 0,2% vom Bereichsendwert ± 0,5% vom Anzeigewert } für Bereiche > 200 kΩ
Temperaturkoeffizient	± 1 Ziffer / 3° für Bereiche ≤ 200 kΩ ± 1 Ziffer / 2° für Bereiche 2 MΩ und 20 MΩ
Messstrom	1 mA für Bereiche 200 Ω und 2 kΩ 10 µA für Bereiche 20 kΩ und 200 kΩ 100 nA für Bereiche 2 MΩ und 20 MΩ
Maximale Spannung an den offenen Messklemmen	< 2,7 V für Bereiche 200 Ω, 20 kΩ und 2 MΩ < 12 V für Bereiche 2 kΩ, 200 kΩ und 20 MΩ
Halbleiter	können in Durchlassrichtung im 2-kΩ Bereich und in Sperrichtung im 2 MΩ- oder 20 MΩ-Bereich geprüft werden.

B ALLGEMEINE ANGABEN

1. Anzeige

Anzahl der Ziffern	3 + 1
Maximale Anzeige	1999
Polarität	Automatische Anzeige des Minuszeichens Keine Anzeige bei positiver Gleichspannung, Wechsel-Spannung und Widerständen
Ueberbereichsanzeige	Die dritte Ziffer von rechts zeigt eine Null an, die anderen Stellen sind dunkel
Dezimalstelle	Wird automatisch mit dem Bereichsschalter umgeschaltet

2. Analog/Digital-Umsetzer

Schaltungsart	Delta-Impulsmodulationssystem*
Abtastrate	2 x pro Sekunde, ein Speicher sorgt während der Messzeit für die Anzeige
Anzeigesteuerung	Laufend mit einer Abtastfrequenz von 512 Hz

3. Eingang

Messeingang	Erdfrei
Bereichsumschaltung	Von Hand
Maximales Gleichtaktsignal	500 V 350 V, 50 Hz
Kapazität "0" - ⊥	1,8 nF
Maximale Spannung zwischen "V-R" und ⊥	1000 V = oder 1000 V_{eff}

4. Temperaturbereich

Umgebungstemperatur	0 ... 45°C
Nullpunktdrift	± 1 Ziffer / 4°C

5. Ueberlastbarkeit

Maximal zulässige Spannungen

Bereich	Wert
Bereiche ≤ 2 V Gleich- und Wechselspannung	350 V =; 300 V~ (50 Hz)
Bereiche > 2 V~	500 V =; 00 V~
Bereiche > 2 V=	1,2 kV=; 600 V~

Bei hochohmigen Spannungsquellen sind die Spannungsbereiche bis 3 kV überlastungsgeschützt

Strombereiche

Eine 6-A Sicherung und Leistungsdioden schützen die Parallel- widerstande. Maximal 250 V Gleich- oder Wechselspannung sind zulässig.

Widerstandsbereiche

Geschützt bis 250 V gleich- oder Wechselspannung (50 Hz)
In den Bereichen ≤ 2 kΩ spricht bei Spannungen über 30 V eine Sicherung von 125 mA an.

* Philips patent

6. Netzanschluss

Netzspannung	110 V oder 220 V ± 15% Eine zusätzliche Anpassung von 18 V ist möglich
Frequenz	40 bis 60 Hz
Leistungsaufnahme	30 VA

C MECHANISCHE DATEN

Abmessungen	Höhe : 145 mm Breite: 236 mm Tiefe : 298 mm
Gewicht	ca. 3,5 kg

III. ZUBEHOER

A. MITGELIEFERTES ZUBEHOERS

Satz Messkabel mit Prüfenspitzen PM 9260
Verbindungslaschen für die Klemmen "0" und ⊥
Anleitung

B. WAHLZUBEHOER

Hochspannungs-Messkopf PM 9246 (Fig. 1, Seite 26)

Mit dem hochspannungs Messkopf PM 9246 können Gleichspannungen bis 30 kV gemessen werden. Der PM 9246 kann benutzt werden für Messinstrumenten mit einen Eingangsimpedanz von 100 MΩ, 10 MΩ und 1.2 MΩ (umschaltbar).

TECHNISCHE DATEN

Zulässige Spannung	30 kV
Abschwächung	1000 x
Eingangsimpedanz	600 MΩ ± 5%
Fehlergrenze	± 3% für Messinstrumenten mit Eingangsimpedanz von 100 MΩ und 10 MΩ. ± 5% für Messinstrumenten mit Eingangsimpedanz von 1.2 MΩ

Achtung:
Für eine gute Erdverbindung muss gesorgt werden.

UHF-Messkopf PM 9200 (Fig. 2, Seite 42)

Mit dem UHF-Messkopf PM 9200 können Wechselspannungen von 10 mV bis 16 V gemessen werden.

Frequenzbereich	100 kHz ... 800 MHz
Fehlergrenze	100 kHz ... 1 MHz ± 10% 1 MHz .. 300 MHz ± 5% 300 MHz .. 800 MHz ± 10%
Eingangsimpedanz	1 MHz : 110 kΩ 10 MHz : 80 kΩ 50 MHz : 25 kΩ
Eingangskapazität	2 pF
Maximal zulässige Spannung am Messkopf	450 V

Bei Frequenzen über 30 MHz gelten diese Toleranzen nur bei Verwendung des T-Stücks PM 9250.

UHF-T-Stück PM 9250 (Fig. 3, Seite 42)

Impedanz	50 Ω
Frequenzbereich	0,1 ... 1000 MHz
Stehwellenverhältnis	0,1 ... 800 MHz : 1,1 800 ... 1000 MHz : 1,2

Stromwandler PM 9245 (Fig. 4, Seite 42)

Mit diesem Transformator lassen sich Wechselströme von 10 A bis 100 A messen

Uebertragungsfaktor	1000 x (100A = 100 mA)
Uebertragungsfehler	± 3%
Frequenzbereich	45 Hz ... 1 kHz
Sekundärspannungsfall	< 200 mV
Maximale Spannung gegen Erde	400 V
Maximaler Luftspalt	0,05 mm

Den Stromwandler vor der Messung an das Instrument anschliessen.
Darauf achten, dass die Berührungsflächen des Joches immer sauber sind.

Shunt PM 9244 (Fig. 5, Seite 42)

Mit Hilfe dieses Shunts lassen sich Gleich- und Wechselströme (max. 1 kHz) bis 31,6 A messen.

Strombereich	10 A und 31,6 A
Ausgangsspannung	100 mV und 31,6 mV
Fehlergrenze	100 mV: ± 1% 31,6 mV: ± 2%
Verlustleistung	max. 3,16 W
Abmessungen	Höhe : 55 mm Breite: 140 mm Tiefe : 65 mm

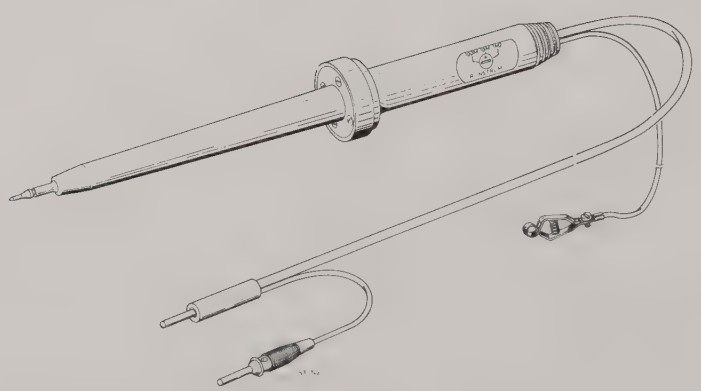


Fig. 1.

IV. WIRKUNGSWEISE (Abb. 8)

A. EINGANGSSCHALTUNG

In der Eingangsschaltung werden alle Eingangsspannungen so umgesetzt, dass am Bereichsendwert jeweils eine Spannung von 2 V zur Verfügung steht, die an den Eingang des AD-Umsetzers weitergeleitet wird.

Im analogen Teil werden alle Eingangssignale, nämlich Gleich- und Wechselspannungen, Gleich und Wechselströme und Widerstände auf dieses Einheitssignal umgesetzt.
Für Gleich- und Wechselspannungen wird derselbe Spannungsteiler verwendet.

Das abgeschwägte Signal kommt an einen Verstärker, der 1 x oder 10 x verstärkt und eine Ausgangsspannung von 2 V = bzw. 2 V_{eff} abgibt.

Bei Wechselspannungsmessungen kommt das Ausgangssignal des Verstärkers an einer Umsetzer, der aus der Wechselspannung eine Gleichspannung macht.

Die an Eingang "I" angeschlossenen Ströme werden mit Hilfe der Parallelwiderstände in Spannungen umgewandelt. Diese Spannungen kommen an den Verstärker mit 1 x oder 10 x Verstärkung und dann direkt, bzw. über den Wechselspannungs/Gleichspannungsumsetzer, an den AD-Umsetzer.

Bei Widerstandsmessungen wird ein konstanter Strom durch den unbekannten Widerstand geleitet. In den einzelnen Bereichen werden folgende Ströme verwendet:

Bereiche	Strom	Messspannung (Endwerte)
200 Ω	1 mA	200 mV
2 kΩ	1 mA	2 V
20 kΩ	10 µA	200 mV
200 kΩ	10 µA	2 V
2 MΩ	100 nA	200 mV
20 MΩ	100 nA	2 V

Die an dem unbekannten Widerstand abfallende Spannung wird über den 1 x oder 10 x Verstärker an den AD-Umsetzer weitergeleitet.

B. DIGITALER TEIL

Der AD-Umsetzer des PM 2422 A arbeitet nach dem Delta-Impulsmodulationsprinzip. Dieses integrierende System garantiert eine hohe Linearität und Unterdrückung von Serienstörspannungen. Ausserdem enthält diese Schaltung ein Minimum an kritischen Bauelementen; die Genauigkeit des AD-Umsetzers hängt nur von der Genauigkeit der Bezugsspannung ab.

Die Prinzipschaltung des AD-Umsetzers ist in Abb. 7 dargestellt. Er funktioniert wie folgt:

Mit einem Komparator wird die Eingangsspannung U_x mit der Spannung U_c verglichen. Die Ausgangsspannung des Komparators steuert über das Flip-Flop FF den Schalter S so, dass entweder die positive Bezugsspannung ($+V_{REF}$), wenn $V_c < V_x$ ist, oder die negative Bezugsspannung ($-V_{REF}$), wenn $V_c > V_x$ ist, mit R1 verbunden ist.

Angenommen, V_x ist positiv gegenüber V_c und Schalter S ist in Stellung $+V_{REF}$. Das bedeutet dass der Kondensator so geladen wird, dass V_c anwächst, bis sie $> V_x$ ist. Sobald $V_c > V_x$ ist, wird bei dem erstfolgenden Taktimpuls das Flip-Flop FF geschaltet; Schalter S kommt in Stellung $- V_{REF}$. Kondensator C1 wird entladen, bis $V_c < V_x$ ist. Dann kommt Schalter S beim nächsten Taktimpuls wieder in die Startposition (S in Stellung $+ V_{REF}$).

Durch diese Kompensationsmethode wird der Mittelwert von V_c gleich V_x. Wenn V_x konstant ist (eine Gleichspannung,) muss die durchschnittliche Ladung von Kondensator C1 ebenfalls konstant sein. Das bedeutet, dass, wenn während einer längeren Periode (Messzeit t_m) integriert wird, die zugeführte Ladung (Q_c) gleich der entnommenen Ladung (Q_d) ist.

Zugeführte Ladung: $Q_c = \frac{+V_{REF} - V_c}{R} \cdot t_c$

Entnommene Ladung: $Q_d = \frac{V_c - (-V_{REF})}{R} \cdot t_d$

also: $V_c = V_x = \frac{t_c - t_d}{t_c - t_d} \cdot V_{REF}$ oder $V_x = \left(\frac{t_c}{t_c + t_d} - \frac{t_d}{t_c + t_d}\right) V_{REF}$

worin t_c die Summe der Ladezeiten, t_d die Summe der Entnahmezeiten während der Messzeit t_m ist ($+V_{REF}$ und $-V_{REF}$ haben denselben absoluten Wert).
Durch Zählen der Taktimpulse während der Ladezeit (t_c) und Subtraktion der Taktimpulse während der Entladezeit (t_d) erhält man die Anzahl der Taktimpulse, die der Eigangsspannung entspricht.

Angenommen: N = gesamte Anzahl der Taktimpulse während t_m

T = Periodendauer der Taktimpulse

t_m = Messzeit = $NT + t_c + t_d$

Wenn während t_c n Taktimpulse kommen, dann kommen während t_d N-n Impulse, so dass

$V_x = nT - \frac{(NT - nT)}{NT} V_{REF} = \frac{2n - N}{N} V_{REF}$. Wenn $2n - N = n'$ = die Anzahl der zu zählenden Impulse, dann

$$n' = V_x \frac{N}{V_{REF}}$$

N ist eine feste Anzahl Impulse, die von einem Zeitgeber geliefert werden; ihr Wert beträgt 2046. Bei einer Bezugsspannung von 2,046 V wird in der Formel

$$n' = 1000\, V_x \quad (V_x \text{ in Volt})$$

(Im PM 2422 A liegt der Kondensator C1 zwischen den Eingängen des Komparators, um eine bessere Unterdrückung von Serienstörspannungen zu erreichen).

Die Impulse werden in einem in zwei Richtungen zählenden Zähler gezählt, der sich in einer integrierten MOS-Schaltung befindet. Diese Schaltung enthält ferner:

- ein Flip-Flop für die Eingangsstufe (FF, wie oben beschrieben)
- zwei Analoge Schalter (S) zum Schalten der positiven und negativen Bezugsspannung
- einen Polaritätsdetektor
- einen Zeitgeber zur Steuerung der Messzeit
- einen Taktoszillator
- eine Impulsausgangsschaltung, die den 4-Dekaden-Zähler steuert.

Die letztgenannte Schaltung zählt die vom AD-Umsetzer gelieferten Impulse.

Die Anzahl der gezählten Impulse wird in einen Speicher übertragen und danach wird der Zähler von einem Rückstellimpuls aus dem AD-Umsetzer auf Null zurückgestellt.
Ein neuer Messzyklus kann nun beginnen.
Ein Multiplexer verbindet nacheinander jede Dekade des Speichers mit der Decodiertreiberstufe; gleichzeitig wird ein Impuls zur Steuerung des Anodenschalters der entsprechenden Anzeigeröhre abgegeben.
Ueber die Decodiertreiberstufe wird die decodierte Zahl auf eine der vier Anzeigeröhre übertragen, deren Anodenschalter geschlossen ist.
Da die Schaltfrequenz 512 Hz beträgt, sieht es so aus, als wenn alle Ziffern gleichzeitig leuchten.

V. INSTALLATION

A. NETZSPANNUNG

Vor dem Anschliessen des Gerätes an das Netz prüfen, ob die richtige Netzspanning eingestellt ist.

Falls erforderlich, die Transformatorwicklungen wie in Fig. 9 gezeigt verbinden.

Bei der Lieferung ist das Gerät auf 220 V eingestellt.

B. SICHERUNG

Darauf achten, dass nur Sicherungen mit dem erforderlichen Stromwert und des richtigen Types verwendet werden. Die Verwendung von reparierten Sicherungen und das Kurzschliessen der Sicherungshalter ist verboten.
Die Netzsicherung ist im Gerät montiert auf der Rückseite (Fig. 32, Seite 101) und muss folgenden Wert haben:

- bei 110 V : 250 mA, träge
- bei 220 V : 140 mA, träge

C. ERDUNG

Das Gerät ist den örtlichen Sicherheitsvorschriften entsprechend zu erden. Dies kann mit einem 3-adrigen Netzkabel erfolgen. Der Netzstecker darf dann nur in eine Schukosteckdose gesteckt werden. Verlängerungs-schnüre, die diese Erdverbindung unterbrechen, dürfen nicht verwendet werden.

VI. BEDIENUNG

A. EINSCHALTEN (fig. 10)

Das Gerät ist nach Anschliessen der Netzspannung und der Erdung betriebsbereit. Es kann mit dem Schalter POWER ON (SK1) eingeschaltet werden.
Die Anzeigeröhren leuchten dann.
Eine Anwärmzeit von ca. 30 min. sollte beachtet werden, damit das Gerät seine volle Genauigkeit erhält.

B. EINSTELLUNG DES ELEKTRISCHEN NULLPUNKTES

- Das Gerät einschalten und ca. 30 min. anwärmen lassen.
- Die Buchsen "o" (BU2) und "V-R" (BU3) miteinander verbinden.
- Taste DC (SK2/1) drücken.
- Den Bereichsschalter (SK3) auf 200 mV stellen.
- Mit Potentiometer "ZERO" (Schraubenziehereinstellung an der Rückseite des Geräts) eine Anzeige von 00.0 einstellen.
- Wenn der Indikator "-" blinkt, ist die Nullpunkteinstellung richtig ausgeführt.

C. KALIBRIERUNG

Dieses Gerät darf nur mit einem Gleichspannungsnormal mit einer Fehlergrenze von höchstens ± 0,04% (besser noch ± 0,02%) kalibriert werden.
Der Kalibriervorgang ist in Kapitel XI, Abschnitt D.1 beschrieben.

D. MESSUNGEN

1. Gleich- und Wechselspannungen (fig. 10)

- Die Art der Messung einstellen, DC-R oder AC.
- Mit dem Bereichsschalter SK1 den richtigen Messbereich einstellen.
- Die zu messende Spannung an die Buchsen "0" (BU2) und V-R (BU3) anschliessen.

Anmerkungen:

- Für erdfreie Messungen ist die Verbindungslasche zwischen "0" (BU2) und ⊥ (BU1) zu entfernen.
- Die Kapazität zwischen Anschluss "0" und ⊥ beträgt ca. 1,8 nF.
- Bei Gleichspannungen zeigt der Polaritätsindikator die Polarität an Buchse V-R gegenüber Nur das Minuszeichen wird angezeigt.
- Zwischen Anschluss "0" und Chassis (⊥) ist eine Gleichspannung von maximal 500 V und eine Wechselspannung von maximal 350 V (50 Hz) zugelassen.
- Zwischen Buchse V-R und dem Chassis (⊥) sind maximal 100 V = oder 1000 V_{eff} erlaubt.
- Maximal zulässige Spannung:

Bereich	Gleichspannungsmessungen	Wechselspannungsmessungen
200 mV 2 V	350 V=; 300 V (50 Hz)	350 V=; 300 V (50 Hz)
20 V 200 V 1000 V	1,2 kV=; 600 V (50 Hz)	500 V=; 600 V (50 Hz)

2. Hochspannungen bis 30 kV mit Messkopf PM 9246

- Taste DC-R drücken
- Den Messkopf an die Büchsen "0" und V-R anschliessen (die Büchsen "0" und ⊥ müssen mit der Lasche miteinander verbunden sein).
- Den Erdungsclip des Messkopfes gut erden
- Der Schalter auf den Messkopf im Bereich 10 MΩ einstellen
- Mit dem Bereichsschalter können folgende Bereiche eingestellt werden:

Bereichsschalter in Stellung	Hochspannungs-Messbereich
20 V	max. 2 kV
200 V	max. 20 kV
1000 V	max. 30 kV (siehe Anmerkung)

Anmerkungen:

- Es dürfen nur Gleichspannungen bis max. 30 kV gemessen werden (Bereichsende ist 100 kV)
- Die Lage der Dezimalstellenanzeige ist zu beachten.

3. UHF-Spannungen (mit Messkopf PM 9200 und T-Stück PM 9250)

- Taste DC-R drücken.
- Den Messkopf an die Büchsen "0" und V-R anschliessen, Erdungsstift an Büchse "0" (Büchsen "0" und ⊥ müssen miteinander verbunden sein)
- Den Messbereichsschalter auf den erforderlichen Wert stellen

Anmerkungen:

- An den Messkopf dürfen Spannungen von maximal 16 V_{eff} angeschlossen werden.
- Der Korrekturfaktor der Eichkurve des Messkopfes muss berücksichtigt werden.

4. Gleich- und Wechselströme

- Taste DC-R oder AC drücken
- Mit Schalter SK 1 den gewünschten Messbereich wählen
- Die Stromquelle an die Büchsen "0" und 1 (BU4) anschliessen.

Anmerkungen:

- Der Polaritätsanzeiger zeigt die Polarität an Büchse 1 gegenüber der an Büchse "0" an. Nur das Minuszeichen wird angezeigt.
- An den Buchsen für die Strommessungen sind Gleich- und Wechselspannungen von maximal 250 V zugelassen.
- Die Parallelwiderstände sind mit einer 6-A-Sicherung geschützt (siehe Kapitel VIII, Abschnitt B).

5. Gleich- und Wechselströme (max. 1 kHz) bis 31,6 A mit dem Parallelwiderstand PM 9244

- Eine der Tasten DC-R oder AC drücken.
- Die Anschlüsse + und - des Parallelwiderstandes PM 9244 an die Büchsen V-R und "0" (BU3 und BU2) anschliessen
- Den Bereichsschalter auf 200 mV stellen.
- Die Stromquelle, je nach Höhe des Stromes, an die Büchsen - und 10 A bzw. 31,6 A anschliessen.
- Mit Schalter SK 1 (Abb. 5) kann die vom Parallelwiderstand PM 9244 abgenommene Spannung von 100 mV auf 31,6 mV umgeschaltet werden.

6. Wechselströme bis 100 A mit dem Stromwandler PM 9245

- Taste AC drücken
- Die Anschlüsse des Stromwandlers PM 9245 an die Buchsen "0" und I anschliessen.
- Den Bereichsschalter auf 200 mA stellen.
- Den stromführenden Leiter in die Oeffnung des Transformators legen.
- Es ist ein Wechselstrom von maximal 100 A zugelassen.
- Frequenzbereich 45 Hz bis 1 kHz.

7. Widerstände

- Taste DC-R drücken
- Den unbekannten Widerstand an die Büchsen "0" und V-R anschliessen.
- Den richtigen Messbereich wählen.

Anmerkungen:

- Die Messströme betragen: 1 mA in den Bereichen 200 Ω und 2 kΩ
  10 µA in den Bereichen 20 kΩ und 200 kΩ
  100 nA in den Bereichen 2 MΩ und 20 MΩ.
- Für das Messen von Widerständen kann der Messclip PM 9261 verwendet werden.
- Halbleiter können in Durchlassrichtung im 2-kΩ-Bereich gemessen werden. Es wird der Spannungsabfall in Durchlassrichtung bei einem Strom von 1 mA angezeigt. Büchse "V-R" (BU3) ist positiv gegenüber Büchse "0" (BU2).

GENERALITES

I. INTRODUCTION

Le multimètre numérique Philips PM 2422 A est un instrument précis à 3 digits + 1 digit de dépassement, à lecture maximale de 1999 permettant de mesurer:

- Les tensions alternatives et continues de 100 µV ... 1000 V (600 V alternatif), 5 gammes
- Les courants alternatifs et continus de 100 nA ... 2 A, 5 gammes
- Les résistances de 0,1Ω ... 20 MΩ, 6 gammes
- Les tensions continues élevées atteignant 30 kV avec la sonde THT PM 9246
- Les tensions UHF atteignant 800 MHz à l'aide de la sonde UHF PM 9200

  Pour les fréquences supérieures à 30 MHz, il est recommandé d'employer le Té connecteur PM 9250 avec cette sonde.
- Les courants alternatifs et continus atteignant 31,6 A avec le shunt PM 9244
- Les courants alternatifs atteignant 100 A à l'aide du transformateur de courant PM 9245.

L'instrument est de manoeuvre aisée.
Le choix des gammes de mesure s'effectue à l'aide d'un commutateur rotatif, le choix entre alternatif et continu à l'aide de touches.
La vergule est positionnée automatiquement par le commutateur de gammes.
Il y a indication automatique de la polarité des tensions et courants continus.
Seul le signe - est affiché.
L'instrument est protégé contre les surcharges dans toutes les gammes jusgu'au moins 250 V.
Cet instrument de conception efficiente convient à toutes les applications de l'électronique moderne.

II. CARACTERISTIQUES TECHNIQUES

Les valeurs numériques tolérances sont garanties par le fabricant.
Les valeurs numériques non-tolérancées sont données à titre d'information générale et représentent les caractéristiques d'un instrument moyen.
Les caractéristiques ci-dessous sont celles de l'instrument à $23^{\circ}C \pm 1^{\circ}C$, auf indication contraire.

A. GAMMES DE MESURE

1. Tensions continues

Gamme de mesure	0.1 mV ... 1000 V 5 gammes à limite supérieure respective de 200 mV, 2 V, 20 V, 200 V et 1 kV

Résolution	100 µV
Précision	± 0,1% de la gamme et ± 0,1% de la lecture
Coefficient de température	± 1 digit / 5°C
Résistance d'entrée	10 MΩ ± 0,2%
Capacité d'entrée	< 100 pF
Réjection mode série	> 66 dB à 50 Hz et 60 Hz
Réjection mode commun	> 120 dB en courant continu, 50 Hz et 60 Hz

2. Tensions alternatives

Gamme de mesure	0,1 mV ... 600 V 5 gammes à limite supérieure respective de 200 mV, 2 V 20 V, 200 V et 600 V.
Résolution	100 µV
Impédance d'entrée	10 MΩ ± 0,2% / maxi 100 pF
Précision	± 0,2% de la gamme et ± 0,2% de la lecture } à la fréquence de 1 kHz ± 0,3% de la gamme et ± 0,3% de la lecture } aux fréquences de 30 Hz ...20kHz ± 0,5% de la gamme et ± 0,5% de la lecture } aux fréquences de 20 Khz ..25kHz
Coefficient de température	± 1 digit / 5°C
Plage de fréquence	30 Hz ... 25 kHz
Tension maximale d'entrée	600 V
Fréquence maximale sur gamme de 600 V	1 kHz

3. Courants continus

Gamme de mesure	100 nA ... 2 A 5 gammes à limite supérieure respective de 200 µA, 2 mA 20 mA, 200 mA et 2 A
Résolution	100 nA
Précision	± 0,3% de la gamme et ± 0,3% de la lecture
Coefficient de température	± 1 digit / 4°C
Perte de tension	< 250 mV pour les courants ≤ 200 mA < 600 mV pour 2 A

4. Courants alternatifs

Gamme de mesure	100 nA ... 2 A 5 gammes à limite supérieure respective de 200 µA, 2 mA, 20 mA, 200 mA et 2 A
Résolution	100 nA
Précision	± 0,4% de la gamme et ± 0,4% de la lecture
Gamme de fréquence	30 Hz ... 1 kHz
Coefficient de température	± 1 digit / 4°C
Perte de tension	< 250 mV pour les courants ≤ 200 mA < 600 mV pour 2 A

5. Résistances

Gamme de mesure	0,1 Ω ... 20 MΩ 6 gammes à limite supérieure respective de 20 Ω, 2 kΩ, 20 kΩ, 200 kΩ, 2 MΩ et 20 MΩ
Résolution	0,1 Ω
Précision	± 0,2% de la gamme et ± 0,2% de la lecture } pour les gammes < 200 kΩ ± 0,2% de la gamme et ± 0,5% de la lecture } pour les gammes de 2 MΩ et 20MΩ
Coefficient de température	± 1 digit / 3°C pour les gammes ≤ 200 kΩ ± 1 digit / 2°C pour les gammes de 2 MΩ et 20 MΩ
Courant de mesure	1 mA pour les gammes de 200 Ω et 2 kΩ 10 µA pour les gammes de 20 kΩ et 200 kΩ 100 nA pour les gammes de 2 MΩ et 20 MΩ
Tension maximale avec entrée non protégé	2,7 V pour les gammes 200 Ω, 20 kΩ et 2 MΩ 12 V pour les gammes de 2 kΩ, 200 kΩ et 20 MΩ
Semi-conducteurs	peuvent être contrôlés dans le sens conducteur sur la gamme 2 kΩ, dans le sens inverse sur les gammes 2 MΩ et 20 MΩ

B. CARACTERISTIQUES GENERALES

1. Affichage

Nombre de digits	3 + 1
Lecture maximale	1999
Polarité	affichage automatique du signe "-" aucune indication pour CC+, CA et ohms
Dépassement de gamme	le digit des centaines affiche un 0, les autres sont supprimées
Virgule	positionnée automatiquement par le sélecteur de gamme

2. Conversion analogique-numérique

Système de conversion	modulation d'impulsion delta *
Cadance d'échantillonnage	2 fois par seconde; la mémoire conserve la valeur affichée pendant le temps de mesure
Commande d'affichage	séquentille; fréquence d'analyse 512 Hz

3. Entrée

Entrée de mesure	flottante
Sélection de gamme	manuelle
Signal maximal mode commun	500 V CC 350 V CA, 50 Hz.
Capacité "0" - ⊥	1,8 nF
Tension maximale entre "V-R" et ⊥	1000 V CC ou 1000 V_{eff}

4. Gamme de température

Température ambiante	0 ... 45°C
Dérive du zéro	± 1 digit / 4°C

5. Protection

Tension maximale admissible

Gamme	Valeur
Gammes ≤ 2 V CC et CA	350 V CC; 300 V CA (50 Hz)
Gammes > 2 V CA	500 V CC; 600 V CA
Gammes > 2 V CC	1,2 kV CC; 600 V CA

Les gammes de tension sont protégées contre les surcharges jusque 3 kV provenant de sources à haute impédance.

Gammes de courant	fusible de 6 A et diodes de puissance pour la protection des shunts. Tension maximale admissible 250 V CC ou CA

* Brevet Philips

Gammes de résistance	Protégées contre 250 V CC ou CA (50 Hz) Pour les gammes $\leq$ 2 kΩ au-dessus de 30 V, fonctionnement d'un fusible (125 mA)

6. Alimentation

Tension secteur	110 V ou 220 V $\pm$ 15% Adaptation supplémentaire par 18 V possible
Fréquence	40 - 60 Hz
Consommation	30 VA

C CARACTERISTIQUES MECANIQUES

Dimensions	hauteur : 145 mm Largeur : 236 mm profondeur: 298 mm
Poids	environ 3,5 kg.

III. ACCESSOIRES

A. FOURNIS AVEC L'APPAREIL

Jeu de cordons de mesure avec pointe de touche PM 9260
Languette d'interconnexion entre bornes "0" et ⊥
Mode d'emploi

B. EN OPTION

Sonde HT PM 9246 (Fig. 1, page 40)

La sonde HT PM 9246 est appropriée à la mesure de tensions continues jusqu'à 30 kV
Il est possible d'utiliser la probe PM 9246 pour des instruments de mesure avec une impédance d'ent d'entrée de 100 MΩ, 10 MΩ et 1.2 MΩ (sélectionable).

CARACTERESTIQUES TECHNIQUES

Tension maximale	30 kV
Attenuation	1000 x
Impédance d'entrée	600 MΩ ± 5%
Précision	± 3% pour instruments avec impédance d'entrée de 100 MΩ et 10 MΩ ± 5% pour instruments avec impédance d'entrée de 1.2 MΩ

Attention:
Veiller à effectuer une bonne connection de terre.

Sonde UHF PM 9200 (Fig. 2, page 42)

La sonde UHF PM 9200 convient à la mesure des tensions alternatives comprises entre 10 mV et 16 V.

Gamme de fréquence	100 kHz ... 800 MHz
Réponse de fréquence	100 kHz ... 1 MHz ± 10% 1 MHz .. 300 MHz ± 5% 300 MHz .. 800 MHz ± 10%
Impédance d'entrée	1 MHz: 110 kΩ 10 MHz: 80 kΩ 50 MHz: 25 kΩ
Capacité d'entrée	2 pF
Tension maximale admissible sur la sonde	450 V CC

Aux fréquences supérieures à 30 MHz, ces tolérances ne sont valables que si on emploie le Té connecteur PM 9250.

Té connecteur UHF PM 9250 (Fig. 3, page 42)

Impédance	50 Ω
Réponse de fréquence	0,1 ... 1000 MHz
Taux d'ondes stationnaires	0,1 ... 800 MHz : 1,1 800 ... 1000 MHz : 1,2

Transformateur de courant PM 9245 (Fig. 4, page 42)

Avec ce transformateur il est possible de mesurer les courants alternatifs supérieurs à 10 A jusque 100 A.

Rapport de transformation	1000 x (100 A = 100 mA)
Erreur de transformation	± 3%
Gamme de fréquence	45 Hz ... 1 kHz
Perte de tension au secondaire	< 200 mV
Tension maximale par rapport à la terre	400 V CA
Entrefer maximal	0,05 mm

Connecter le transformateur de courant à l'instrument avant d'effectuer la mesure.
Eviter la pollution des composants du circuit magnétique.

Shunt PM 9244 (Fig. 5, page 42)

Ce shunt permet de mesurer des courants continus et alternatifs (1kHz maxi) jusque 31,6 A.

Gamme de courant	10 A et 31,6 A
Tension de sortie	100 mV et 31,6 mV
Précision	100 mV: ± 1% 31,6 mV: ± 2%
Dissipation de puissance	3,16 W maxi
Dimensions	hauteur : 55 mm largeur : 140 mm profondeur: 65 mm

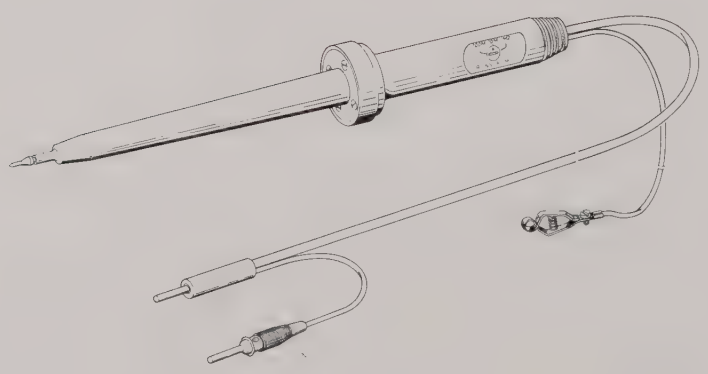


Fig. 1.

IV. PRINCIPE DE FONCTIONNEMENT (fig. 8)

A. CIRCUIT D'ENTREE

Le rôle du circuit d'entrée est de fournir une tension continue de 2 V à l'entrée du convertisseur analogique-numerique aux valeurs limites des gammes.

La partie analogique transfère tous les signaux d'entrée, c'est à dire les tensions continues et alternatives, les courants continus et alternatifs et les résistances, à ce signal de 2 V.
Le même diviseur est employé pour les tensions continues et alternatives.

Le signal atténué est transmis à un amplificateur 1 x ou 10 x à sortie de 2 V CC ou 2 $V_{eff.}$

Dans le cas des mesures de courants alternatifs, le signal de sortie de l'amplificateur est transmis à un convertisseur alternatif/continu, il est hors circuit si l'on mesure des courants continus.

Les courants fournis à l'entrée I sont transformés en tensions par des shunts. Ces tensions sont également fournies à l'amplificateur 1 x ou 10 x, puis fournies au convertisseur analogique/digital, soit directement, soit via le convetisseur alternatif/continu dans le cas des courants alternatifs.

Pour les mesures de résistance, on fait passer un courant constant par la résistance inconnue.
Les courants suivants sont employés dans les différentes gammes:

Gammes	Courant	Tension de mesure (pleine échelle)
200 Ω	1 mA	200 mV
2 kΩ	1 mA	2 V
20 kΩ	10 µA	200 mV
200 kΩ	10 µA	2 V
2 MΩ	100 nA	200 mV
20 MΩ	100 nA	2 V

La tension de mesure aux bornes de la résistance inconnue est transmise au convertisseur analogique-numérique via l'amplificateur 1x ou 10x.

B. PARTIE NUMERIQUE

Le convertisseur analogique-numérique du PM 2422 A est basé sur le principe de la modulation d'impulsion delta.
Ce système d'intégration assure une bonne linéarité et une bonne réjection mode série.
De plus, le circuit contient un minimum d'éléments critiques; seule la précision de la tension de référence est importante pour la précision du convertisseur analogique-numérique.

Le circuit de base du convertisseur est représenté sur la fig. 7. Son fonctionnement est le suivant:
A l'aide d'un comparateur, la tension d'entrée V_x est comparée à la tension V_c. La sortie du comparateur commande le commutateur S via le basculateur bistable FF de telle manière que la tension de référence positive ($+V_{REF}$) soit connectée à R1 si $V_c < V_x$, la tension de référence négative ($-V_{REF}$) si $V_c > V_x$.

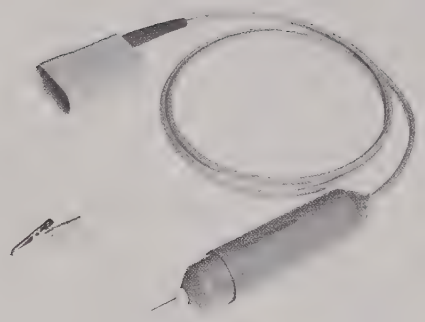


Fig. 2

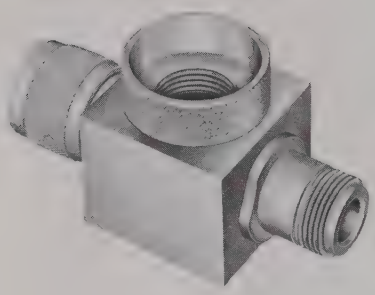


Fig. 3

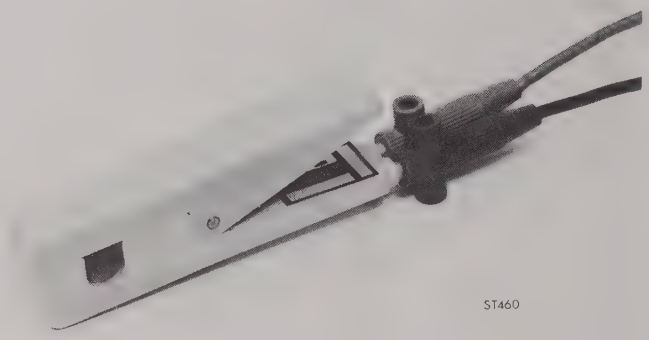


Fig. 4

Fig. 5

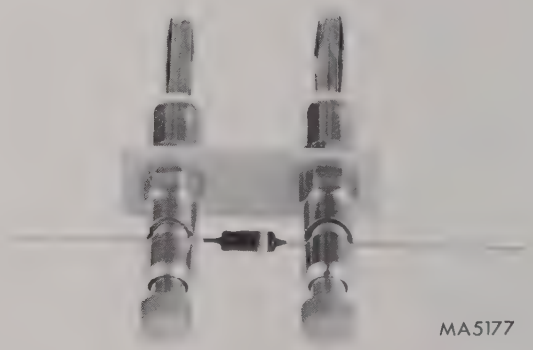


Fig. 6

Supposons que V_x soit positif par rapport à V_c et le commutateur S à la position $+V_{REF}$. Il en résulte que le condensateur se charge, de telle sorte que V_c augmente jusqu'à ce qu'il soit plus grand que V_x. A la prmière impulsion d'horloge après que V_c woit devenu plus grand que V_x, le basculateur bistable FF fonctionne et le commutateur S passe à la position $-V_{REF}$. Le condensateur C1 se décharge jusqu'à ce que V_c devienne plus petit que V_x. Le commutateur S reprend la position de départ (position $+V_{REF}$) à l'impulsion d'horloge suivante.

Grâce à cette méthode de compensation, la valeur moyenne de V_c est égale à V_x. Si V_x a une valeur constante (un niveau continu), la charge moyenne du condensateur C1 doit également être constante. Cela signifie que la charge reçue (Q_c) est égale à la charge perdue (Q_d), si l'on intégre sur une durée de temps prolongée (temps de mesure t_m).

Charge reçue : $$Q_c = \frac{+V_{REF} - V_c}{R} \cdot t_c$$

Charge perdue : $$Q_d = \frac{V_c - (-V_{REF})}{R} \cdot t_c$$

par suite : $$V_c = V_x = \frac{t_c - t_d}{t_c + t_d} \cdot V_{REF} \text{ ou } V_x = \left(\frac{t_c}{t_c + t_d} - \frac{t_d}{t_c + t_d}\right) V_{REF}$$

où t_c = somme des temps de décharge au cours du temps de mesure t_m ($+V_{REF}$ et $-V_{REF}$ ont la même valeur absolue). Si l'on compte le nombre d'impulsions d'horloge au cours du temps de charge (t_c) et qu'on soustrait les impulsions d'horloge au cours des temps de décharge (t_d) on obtient un nombre d'impulsions d'horloge qui correspond à la tension d'entrée.

Supposons que t_m = temps de mesure = $NT = t_c + t_d$

N = nombre total d'impulsions d'horloge au cours de t_m

T = période d'impulsions d'horloge

Si, au cours de t_c, n impulsions d'horloge sont utilisées, au cours de t_d, N-n impulsions sont utilisées, de sorte que V_x devient:

$U = \frac{2n - N}{N} V_{REF}$. Si $2n - N = n'$ = nombre d'impulsions à compter, on a:

$$n' = V_x \frac{N}{V_{REF}}$$

$$U \quad V_x = \frac{nT - (NT - nT)}{NT} V_{REF}$$

N est un nombre fixe d'impulsions déterminé par une minuterie et s'élève à 2046. Si l'on emploie un tension de référence de 2046 V, la formule devient

$$n' = 1000\ V_x \quad (V_x \text{ en volts}).$$

(Dans le condensateur PM 2422 A, C1 est connecté entre les entrées du comparateur pour obtenir une meilleure réjection mode série).

Le comptage des impulsions est effectué par un compteur double inclus dans un circuit intégré MOS. Ce circuit contient en outre:

- Un basculateur bistable d'entrée (FF, décrit précédemment)
- Deux commutateurs analogiques (S) pour commuter les tensions de référence positive et négative
- Un détecteur de polarité
- Une minuterie pour déterminer le temps de mesure
- Un oscillateur d'horloge
- Un circuit de sortie d'impulsions qui commande le compteur à 4 décades.

Ce dernier circuit compte les impulsions fournies par le convertisseur analogique-numérique.

Le nombre des impulsions comprées est transmis à une mémoire après quoi le compteur est remis à zéro par une impulsion du convertisseur analogique-numérique.
Un nouveau cycle de mesure peut alors commencer.
Un multiplexeur connecte alternativement chaque décade au décodeur-driver; en même temps, une impulsion de commande est fournie au commutateur d'anode du tube indicateur correspondant.
Le nombre décodé est transmis via le décodeur-driver à l'un des 4 tubes indicateurs, dont les cathodes sont commutées en parallèle.
Seul l'indicateur dont le commutateur d'anode est fermé s'allume.
La commutation s'effectuant 512 fois par seconde, tous les indicateurs paraissent allumés simultanément.

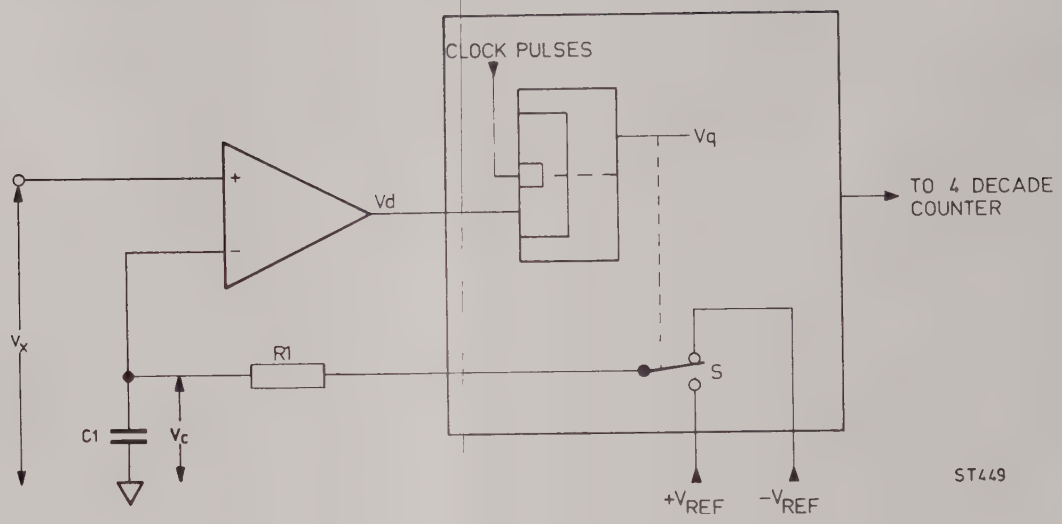

CLOCK PULSES
Vq
TO 4 DECADE COUNTER
Vd
Vx
R1
S
C1
Vc
+VREF
-VREF
ST449

Fig. 7

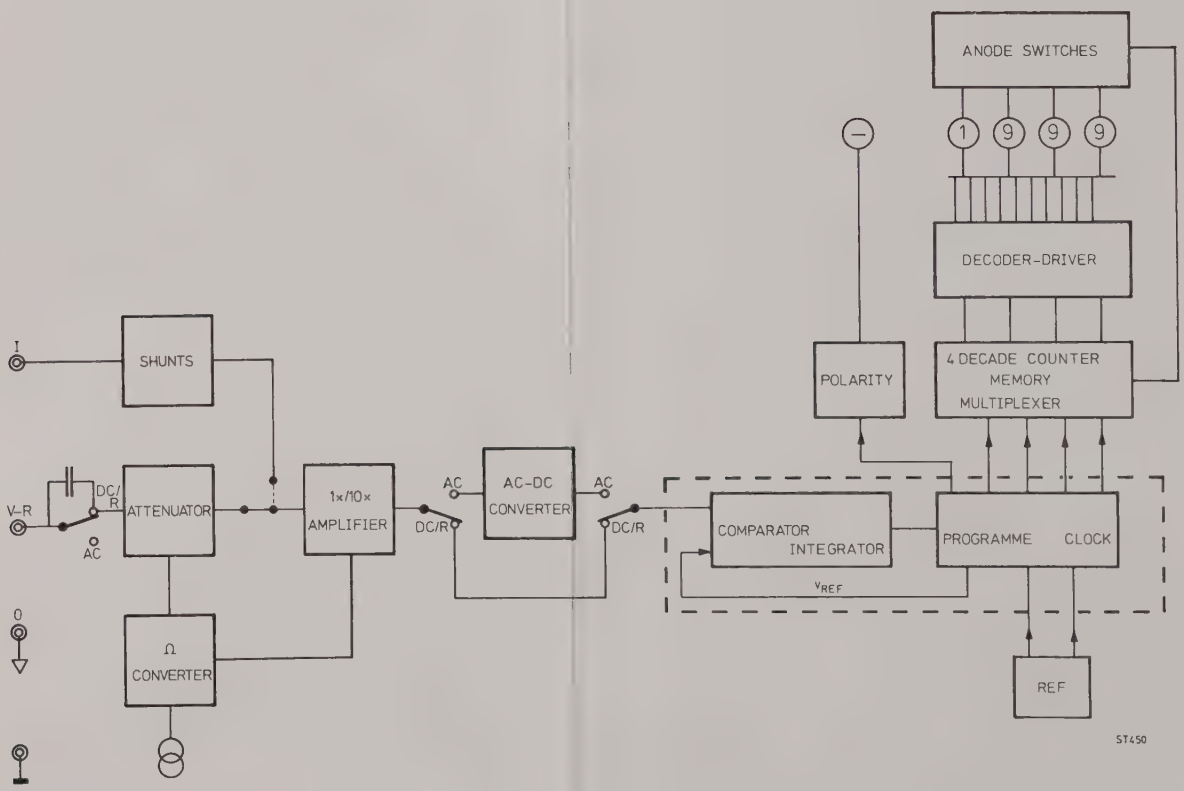

ANODE SWITCHES
1
9
9
9
DECODER-DRIVER
POLARITY
4 DECADE COUNTER MEMORY MULTIPLEXER
I
SHUNTS
V-R
DC/R
AC
ATTENUATOR
1×/10×
AMPLIFIER
AC
DC/R
AC-DC CONVERTER
AC
DC/R
COMPARATOR INTEGRATOR
PROGRAMME
CLOCK
VREF
Ω
Ω CONVERTER
REF
ST450

Fig. 8

V. MISE EN PLACE

A. ALIMENTATION SECTEUR

Avant de brancher l'instrument sur l'alimentation secteur, s'assurer qu'il est réglé sur la tension locale.

Le cas échéant, connecter les enroulements du transformateur comme le montre la fig. 9.

L'instrument est réglé en usine sur 220 V.

B. FUSIBLE

S'assurer que seuls des fusibles de l'intensité nominale requise et du type spécifié sont utilisés. L'emploi de fusibles réparés et la mise en court-circuit des porte-fusibles sont interdits. L'intensité nominale du fusible secteur monté dans l'appareil sur le panneau arrière (fig. 32, page 101) doit être:

- pour 110 V : 250 mA, temporisé
- pour 220 V : 140 mA, temporisé

C. MISE A LA TERRE

L'instrument doit être connecté à la terre conformément aux règlements de sécurité locaux. Cela peut s'effectuer via un cordon secteur à trois conducteurs. La prise de la fische secteur doit être équipée d'un contact de mise à la terre, dont l'action protectrice ne soit pas annulée par l'emploi d'un cordon ou dispositif prolongateur sans conducteur de protection.

VI. MISE EN OEUVRE

A. MISE EN CIRCUIT (fig. 10)

L'instrument est prêt à fonctionner après connexion au secteur et à la terren. Il se met en circuit à l'aide du commutateur secteur POWER ON (SK 3).
Les tubes d'affichage s'allument alors.
Il faut laisser l'instrument s'échauffer pendant environ 30 min. pour obtenir une précision totale.

B. REGLAGE DU ZERO ELECTRIQUE

- Mettre l'instrument en circuit et le laisser s'échauffer pendant environ 30 min.

- Interconnecter les bornes "O" (BU2) et "V-R" (BU3)
- Enfoncer la touche DC (SK2/1)
- Mettre le sélecteur de gamme (SK1) à la position 200 mV
- Régler la valeur indiquée sur 0,00 au moyen du potentiomètre "ZERO" (réglage à l'arrière de l'instrument à l'aide d'un tournevis)
- Si l'indicateur "-" clignote, c'est signe que le réglage du zéro a été effectué correctement.

C. ETALONNAGE

Il n'est possible d'effectuer l'étalonnage de cet instrument que si l'on dispose d'un calibre de courant continu d'une précision d'au moins ± 0,04% (de préférence ± 0,02%).
En ce qui concerne l'étalonnage, prière de se référer au chapitre XI paragraphe D 1.

D. MESURE

1. Tensions continues et alternatives. (fig. 10)

- Choisir le mode de mesure DC-R ou AC
- Choisir la gamme de mesure correcte à l'aide du sélecteur de gamme SK1
- Connecter la tension d'essai aux bornes "O" (BU2) et V-R (BU3)

Remarques:

- Pour les mesures flottantes, enlever la langquette d'interconnexion entre "O" (BU2) et ⊥ (BU1)
- La capacité entre les bornes "O" et ⊥ est environ 1,8 nF
- L'indicateur de polarité indique la polarité des tensions continues sur la borne V-R par rapport à la borne "O". Seul le signe "-" est affiché.
- La tension maximale admissible entre la borne "O" et le châssis ⊥ est 50 V CC ou 350 V CA, 50 Hz.
- La tension maximale admissible entre la borne V-R et le châssis ⊥ est 1000 V CC ou 1000 V_{eff}
- Tension maximale admissible:

Gamme	Mode de mesure CC	Mode de mesure CA
200 mV 2 V	350 V CC; 300 V CA (50 Hz)	350 V CC; 300 V CA (50 Hz)
20 V 200 V 1000 V	1,2kV CC; 600 V CA (50 Hz)	500 V CC; 600 V CA (50 Hz)

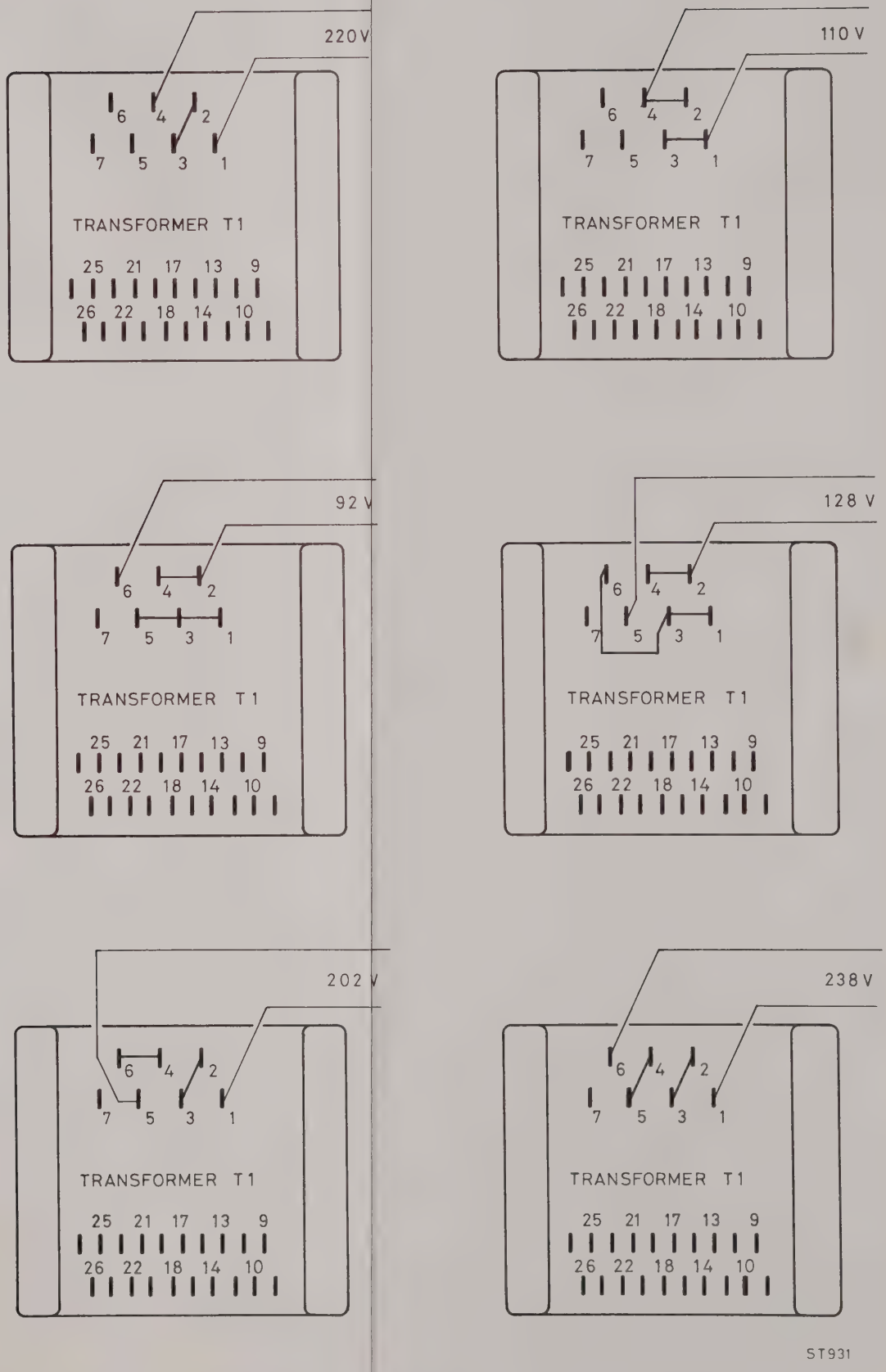

220V
6 4 2
7 5 3 1
TRANSFORMER T1
25 21 17 13 9
26 22 18 14 10
110 V
6 4 2
7 5 3 1
TRANSFORMER T1
25 21 17 13 9
26 22 18 14 10
92 V
6 4 2
7 5 3 1
TRANSFORMER T1
25 21 17 13 9
26 22 18 14 10
128 V
6 4 2
7 5 3 1
TRANSFORMER T1
25 21 17 13 9
26 22 18 14 10
202 V
6 4 2
7 5 3 1
TRANSFORMER T1
25 21 17 13 9
26 22 18 14 10
238 V
6 4 2
7 5 3 1
TRANSFORMER T1
25 21 17 13 9
26 22 18 14 10
ST931

Fig. 9.

2. Tensions THT jusque 30 kV avec sonde PM 9246

- Choisir le mode de mesure DC-R
- Connecter la sonde aux bornes "0" et V-R (les bornes "0" et ⊥ doivent être interconnectées par la languette appropriée)
- Connecter convenablement la sonde à la terre
- Sélecter la gamme de 10 MΩ de la sonde
- Le sélecteur de gammes offre les possibilités suivantes:

Position de sélecteur de gamme	Gamme HT
20 V	2 kV maxi
200 V	20 kV maxi
1000 V	30 kV maxi (voir remarques)

Remarques:

- Tension continue maximale admissible 30 kV (la valeur limite de la gamme est 100 kV)
- Vérifier la position de la virgule.

3. Tension UHF (avec sonde PM 9200 et Té connecteur PM 9250)

- Choisir le mode de mesure DC-R
- Connecter la sonde aux bornes "O" et V-R, la broche de mise à la terre étant connectée à la borne "O" (les bornes "O" et ⊥ doivent être interconnectées).
- Mettre le sélecteur de gamme de mesure à la position désirée.

Remarques:

- La tension maximale admissible sur la sonde est 16 V_{eff}
- Tenir compte du facteur de correction de la courbe d'étalonnage de la sonde.

4. Courants continus et alternatifs

- Choisir le mode de mesure DC-R ou AC
- Choisir la gamme de mesure correcte à l'aide du sélecteur SK1.
- Connecter la source de courant à mesurer aux bornes "O" et I (BU4)

Remarques:

- L'indicateur de polarité indique la polarité à la borne I par rapport à la borne "O". Seul le signe "-" est affiché.
- Tension maximale admissible sur les bornes d'intensité dans toutes les gammes 250 V CC ou CA.
- Les shunts sont protégés par un fusible de 6 A (voir chapitre VIII, section B)

5. Courants continus et alternatifs (1 kHz maxi) jusque 31,6 A avec shunt CC PM 9244.

- Choisir le mode de mesure DC-R ou AC
- Connecter les prises de sorties + et - du shunt PM 9244 aux bornes V-R et "O" (BU3 et BU2)
- Mettre le sélecteur de gamme à la position 200 mV
- Connecter la source de courant aux bornes - et 10 A ou 31,6 A suivant le courant à mesurer.
- Le commutateur SK1 (fig. 5) permet de faire passer la tension de sortie du shunt PM 9244 de 100 mV à 31,6 mV.

6. Courants alternatifs jusque 100 A avec transformateur de courant PM 9245

- Choisir le mode de mesure AC
- Connecter les bornes du transformateur PM 9245 aux bornes "O" et I
- Mettre le sélecteur de gamme à la position 200 mA
- Faire passer le conducteur porteur du courant par l'ouverture du transformateur
- Courant alternatif maximal admissible 100 A
- Gamme de fréquence 45 Hz - 1 kHz.

7. Résistances

- Choisir le mode de mesure DC-R
- Connecter la résistance inconnue aux bornes "O" et V-R
- Choisir la gamme de mesure correcte.

Remarques:

- Le courant de mesure est: 1 mA pour les gammes 200 Ω et 20 kΩ
  10 µA pour les gammes 20 kΩ et 200 kΩ et
  100 nA pour les gammes 2 MΩ et 20 MΩ
- On peut employer le dispositif de raccordement PM 9261 pour la mesure des résistances.
- Les semi-conducteurs peuvent être mesurés dans le sens direct sur la gamme de 2 kΩ.
  La valeur affichée et la tension de la diode dans le sens direct sous un courant de 1 mA.
  La borne "V-R" (BU3) est positive par rapport à la borne "O" (BU2).

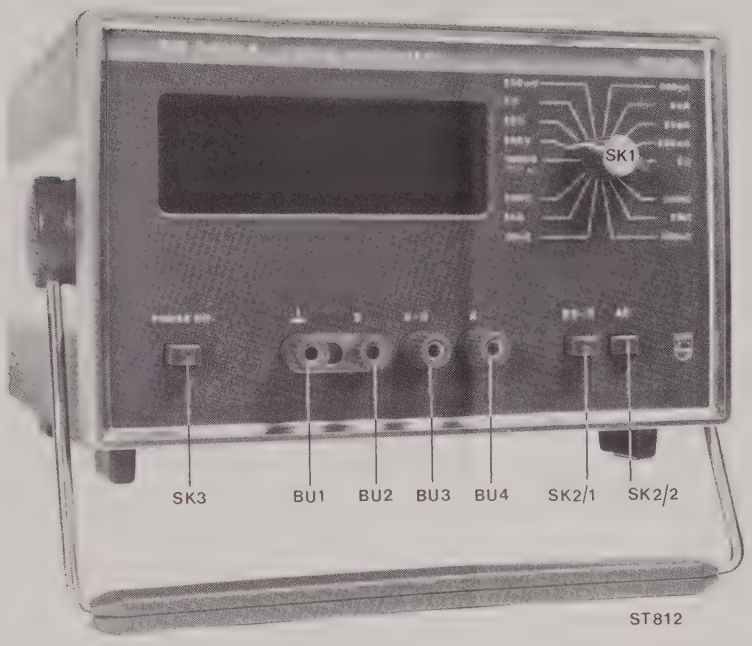

SK1
SK3
BU1
BU2
BU3
BU4
SK2/1
SK2/2
ST812

Fig. 10.

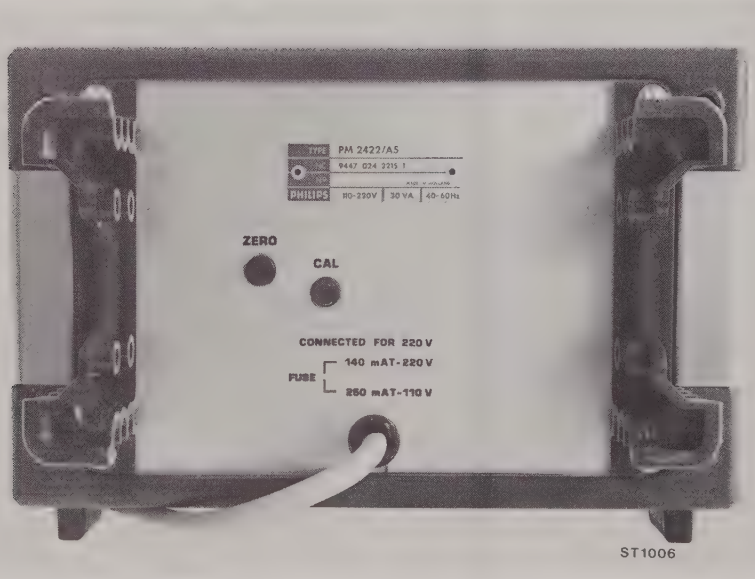

TYPE PM 2422/A5
PHILIPS
110-220V | 30 VA | 40-60Hz
ZERO
CAL
CONNECTED FOR 220 V
FUSE
140 mAT-220 V
250 mAT-110 V
ST1006

Fig. 11.

A. ANALOG SECTION

The analog section of the instrument serves to convert all modes to be measured into a voltage level of + or -2 V in order to obtain a maximum display.
This voltage is supplied to the digital section, which has a constant input-sensitivity of 2 V for maximum display.

1. DC voltage circuit

The input circuit for direct voltage measurements is shown in Fig. 12. The attenuation for the various ranges is given in the table below.

Range	Attenuation	Input amplifier (at end-of-range)
200 mV	1x	0.2 V
2 V	1x	2 V
20 V	100x	0.2 V
200 V	100x	2 V
1000 V	1000x	1 V

The attenuated input voltage is supplied to an amplifier, the gain of which is switchable between 1x and 10x by means of wafer SK1/II f. The output voltage of the amplifier is always 2 V at end-of-range.
Spark-gap VL102, which conducts at voltages over 1700 V, serves to protect switch SK1.

2. AC voltage circuit

The circuit for alternating voltage measurements is shown in Fig. 12 and is in principle equal to the circuit for direct voltage measurements.
However, for the a.c. behaviour the attenuator resistors are shunted by capacitors C101 up to C105.
After being amplified 1 or 10 times the alternating voltage (always 2 V a.c. at end-of-range) is supplied to an a.c.-to-d.c. converter.
The output direct voltage is supplied to the analog-to-digital converter.

3. Direct and alternating current circuit

The circuit for current measurements is shown in Fig. 13.
The current to be measured is converted into a voltage by means of shunts (R116 ... R120).
The voltage across the shunt is 0.2 V at end-of-range, thus the 1x/10x amplifier is set to position 10x for all current ranges.
For alternating currents the a.c.-to-d.c. converter is switched in after the amplifier.

The current ranges are protected by a 6A-fuse (VL103)
If the voltage across the shunt, caused by too high a current or by supplying an excessive voltage to the current input, is larger than about 1.4 V diodes GR101/GR103 or GR102/GR104, depending on the polarity, become conductive. The current through the diodes is restricted by R112 up to R115.

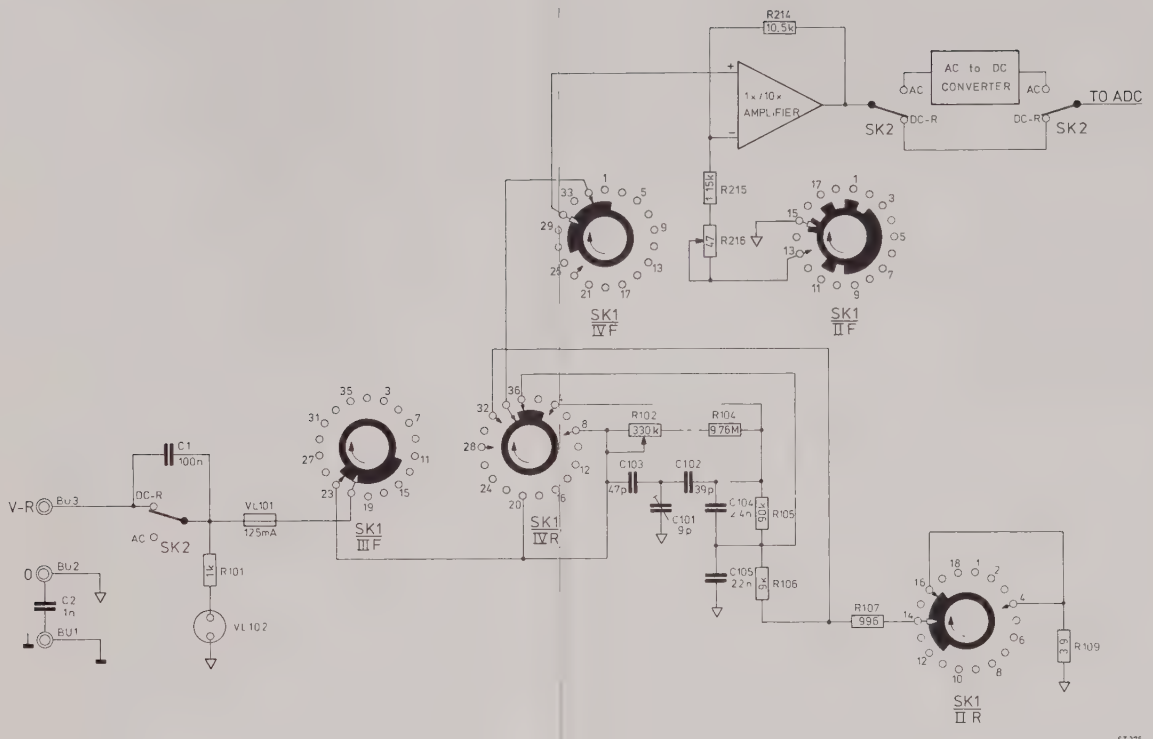


Fig. 12. Direct and alternating voltage measuring circuit

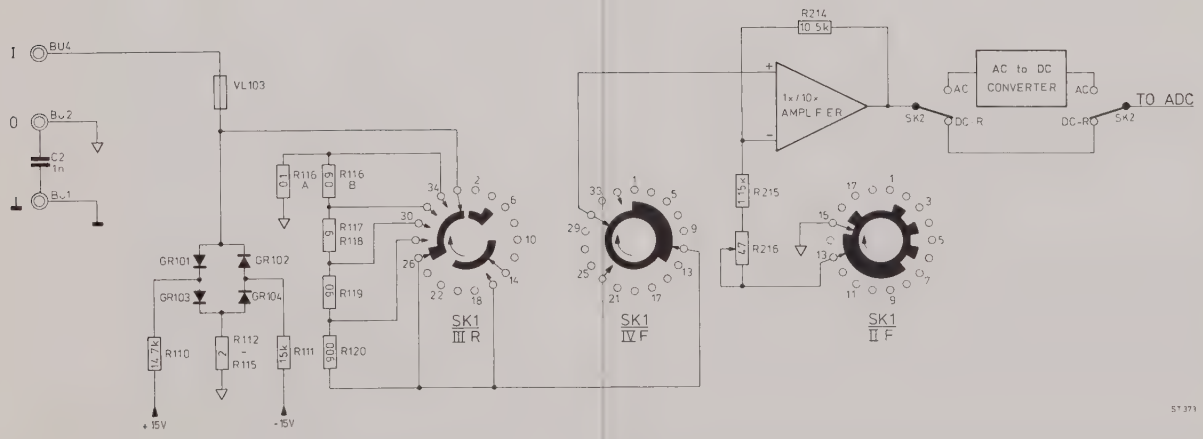


Fig. 13. Direct and alternating current measuring circuit

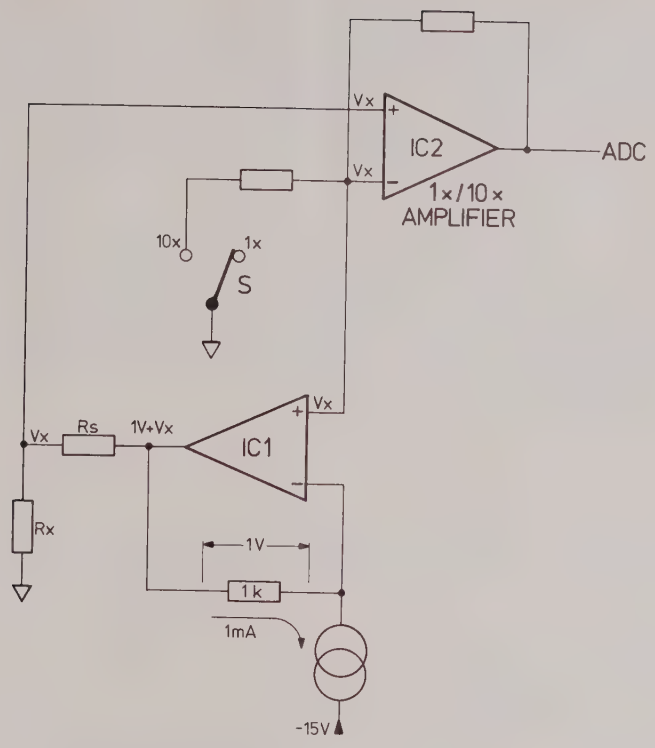


Fig. 14. Principle of resistance measurements ST 367

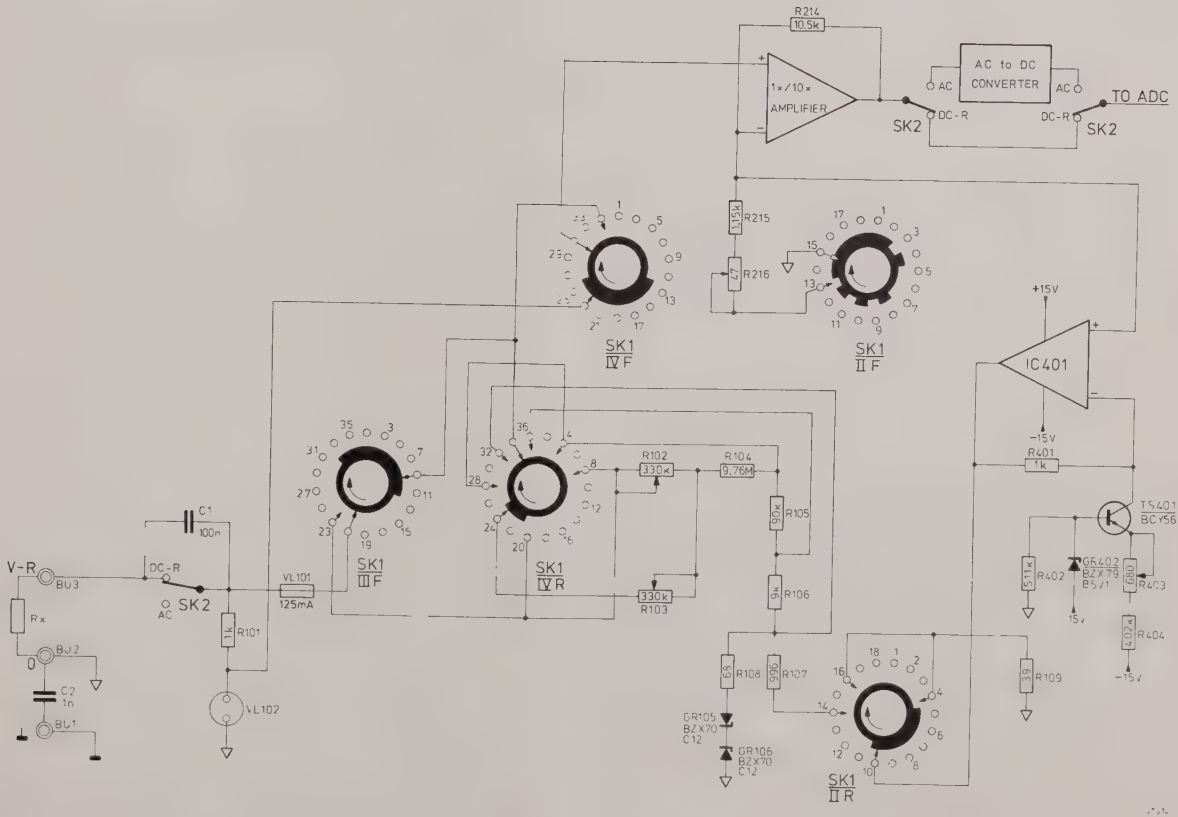


Fig. 15. Resistance measuring circuit

For d.c. measurements capacitor C203 is connected to circuit zero via FET switch TS204, thus forming together with R201 and R202 an RC-filter by which a.c. voltages are suppressed.
For a.c. measurements an improvement of the frequency response is achieved by C201 + C202//R202.

The gate-leackage current of TS203 is kept low by making the source-drain voltage low by means of zener diode GR201.

Protection

The protection of the amplifier is made by transistors TS201 and TS202. By connecting bases and collectors two zener diodes are obtained the zener voltage of which is approximately 8 V with a low leackage current. If the voltage at point TP202 exceeds 8 V the transistors become conductive and limit the gate-voltage of TS203.
The input current is limited by R201 and R202.

6. AC-to-DC converter (Fig. 17)

The supplied voltage which is always 2 $V_{r.m.s.}$ at range-end-values in all ranges is converted to 2 V d.c.
To eliminate the non-linearity of the diode characteristic an operational amplifier with a high open-loop gain is used (IC301).
The gain for positive periodes is determined by the ratio $\frac{R309}{R301 + R302}$, for negative periodes by the ratio $\frac{R308}{R301 + R302}$ and should be 2.22 (twice the form factor).
As IC301 is controlled at the inverting input the input impedance of the converter is low (about 4.5 kΩ).
However, the converter is preceeded by the 1x/10x amplifier which serves as a buffer.
A separate d.c. feedback branche (R303-R306) is used to decrease the drift of IC301. However, it is decoupled for a.c. by C307.
Offset compensation is made by potentiometer R304 and indirectly used to adjust the linearity at small input voltages.
Potentiometer R302 is used to make end-of-range calibration.

B. DIGITAL SECTION

The digital section of the instrument serves to convert the supplied d.c. voltage from the analog section into a decimal information corresponding to the input signal.
The digital section contains the following circuits:
- $+V_{REF.}$ and $-V_{REF.}$
- Analog-to-digital converter (ADC)
- Display

1. $+V_{REF.}$ and $-V_{REF.}$ (Fig. 18)

These voltages are required as reference voltage for the ADC.
The positive reference voltage is achieved via zener diode GR602 (50 ppm/°C) controlled from a current source. With voltage divider R603 + R604 + R605/R608 an output voltage of 2.046 V is obtained which can be adjusted by potentiometers R603 and R604 (available at the rear).
The negative reference voltage is achieved by inverting $+V_{REF.}$ via an amplifier with a gain of -1.
Potentiometer R612 can be used to correct differences in "on" resistances and switching times of the switches in the ADC.

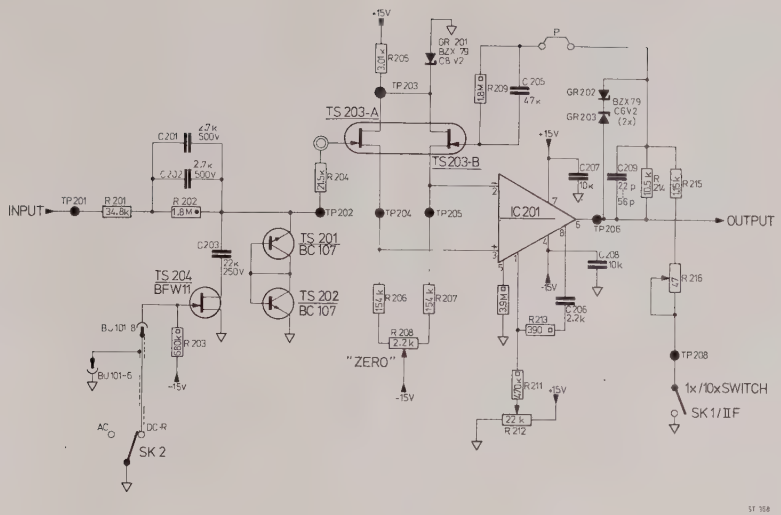


Fig. 16. 1x/10x Amplifier

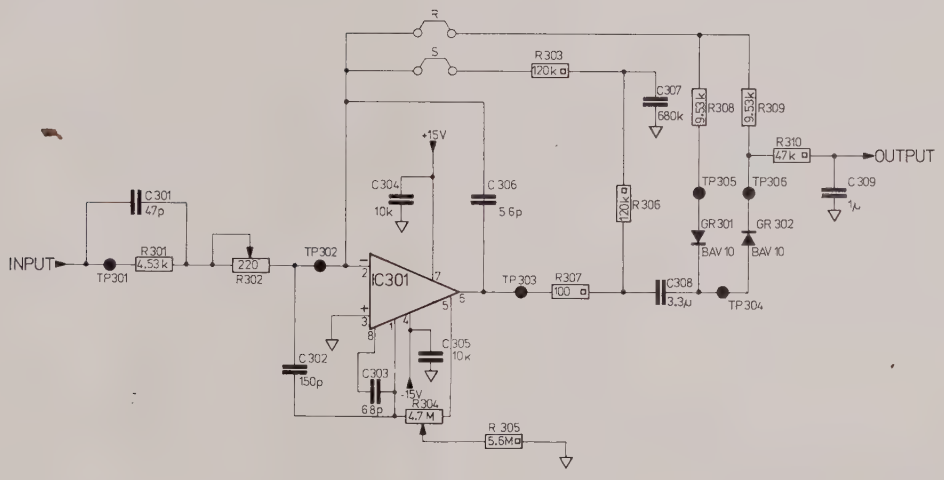


Fig. 17. AC-to-DC converter

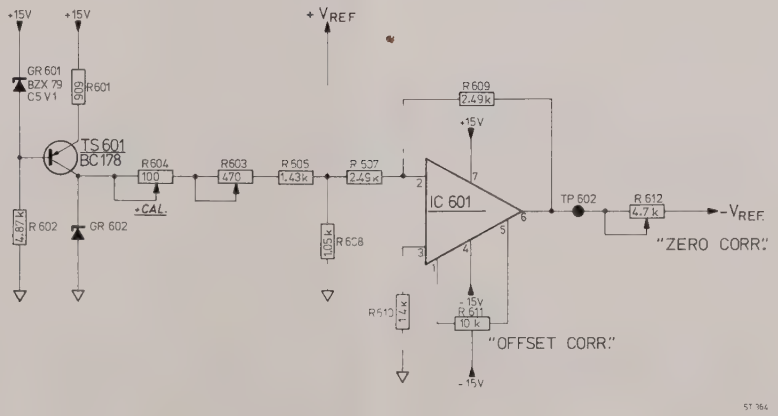


Fig. 18. $+V_{REF.}$ and $-V_{REF.}$ circuit

2. Analog-to-digital converter (ADC)

The used system is derived from the delta pulse modulation principle.
For the function of the ADC, refer to chapter IV, sub-point B.

Practical execution

In PM 2422A this system is obtained as shown in Fig. 19.
The comparator consists of TS501 with a constant current source (TS502) followed by an amplifier (IC501) fed back for a.c.

The subtracting of pulses as described before is effected by an up-down counter which is included in IC502.
This (P-channel-MOS) integrated circuit comprises also the next circuits:

- Input flip-flop, connection point 3.
  This flip-flop sets the analog switches, which select the reference voltage.
- Analog switch: input at point 16 ($+V_{REF.}$) and point 14 ($-V_{REF.}$), output at point 15.

- Synchronisation circuit:
  input : point 13
  outputs : the reset pulse (11)
  the transfer pulse (4)
  the scan pulse (2)
  If the input becomes logical 0 the measuring cycle is started at the first positive edge supplied by the input flip-flop, so that jitter and stalling of the digital part of the ADC are prevented.
- Polarity output circuit, output 12.
  This circuit detects the polarity of the input voltage. If the output is logical 1 the polarity is negative; if, however, it is logical 0 the polarity is positive.
- Pulse output circuit, output 5.
  During the measuring time, the ADC pulses are supplied to the display via output 5.

Remark

The scanning output supplies a signal with a frequency of 512 Hz and a duty cycle of about 1:15 at a clock frequency of 8.2 kHz.

This 512 Hz pulse feeds the scanning system of the display.

3. Clock oscillator (Fig. 20)

The clock pulse is derived from the programmable U.J.T. TS503.
The oscillator frequency is adjustable with R515. This frequency should be 8.2 kHz. By this the frequency of the scanning output of IC502 will be 512 Hz.

4. Display

The display is divided in the following blocks

- 4-decade counter/register (multiplexed output)
- decoder driver
- anode switches
- overrange detector

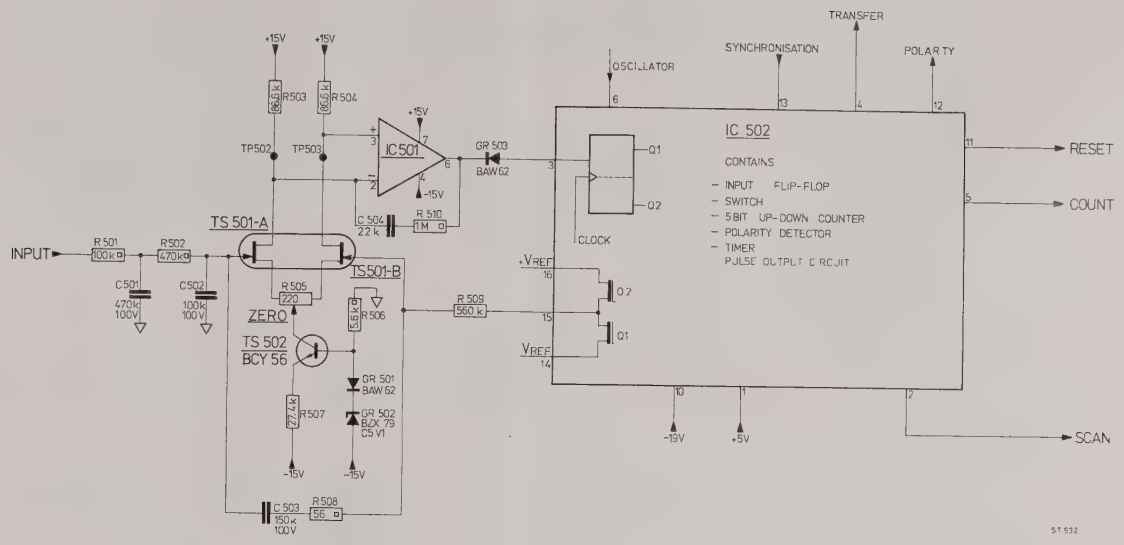


Fig. 19. Analog-to digital converter

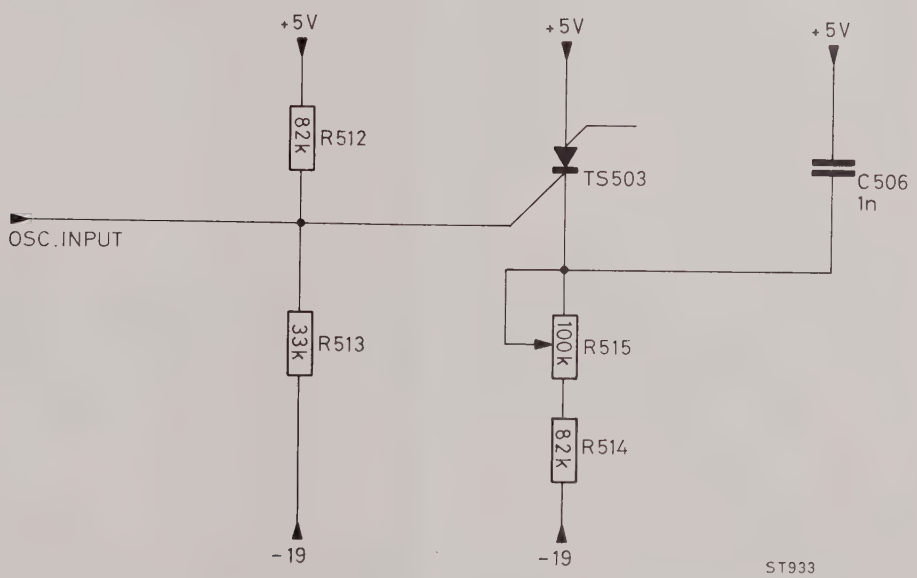


Fig. 20. Monostable multivibrator

a. 4-decade counter/register (Fig. 21)

This counter is a monolitic (P-channel-MOS) integrated circuit and contains
- four decade counters connected in series in such a way that the supplied pulses are converted into a BCD-code per decade.
- four buffer-registers which store the digital information from the decade counters.
- a multiplexer which converts the BCD parallel information into a serial form and transfers the digital information to the input of a decoder-driver synchronously with the relevant anode switch.
- a scaler-of-four which converts the scan frequency with a decoder, by means of a 1 out 4 code to drive the anode switches.

b. Decoder driver

The decoder driver converts the supplied BCD information into a decimal figure and controls the indicators 10^0, 10^1, 10^2 and 10^3 from which the cathodes are parallel-connected.

c. Anode switches (Fig. 22)

The indicators are controlled via 4 anode switches (TS707...TS710), which in turn are driven by signals "Scan 10^3", "Scan 10^2", "Scan 10^1" and "Scan 10^0" supplied by IC701 (see 4.a.).

Via a differentiating network (e.g. C702-R716) pulse "Scan 10^3" (a negative pulse) is applied to the base of TS707. The negative-going edge turns on TS707; thus the corresponding indicator anode (10^3) is connected to the +185 V supply.
At the positive-going edge TS707 is blocked.
GR710/GR712/GR714/716 limit V_{BE} of the anode switches at the positive edge; while GR713/GR715/GR718 limit the V_{CE}.
To block the transistors TS707...TS710 the emitter is biased with respect to the base by means of stabistor GR717.
Sequence diagram Fig. 23 gives a short survey of the working.

d. Overrange detector (Fig. 24)

If the read-out exceeds 1999 the overrange detector detects both the logical levels of signals DATA OUT "B" (logical 1) and SCAN 10^3 (logical 0). The output voltage of the detector becomes logical 1 (5 V) thus blocking the pulses SCAN 10^0 and SCAN 10^1. The corresponding indicators extinguish. Only indicator B703 (10^2) lights and shows a 0 because the maximum display is 2046. Furthermore the "2" indication for the thousands is not built in.

C. SUPPLY (Fig. 35, blz. 67)

1. +185 V source

This source serves to supply the indicators (B702...B705) and is stabilized via a series-stabilisation circuit.
The reference voltage, derived from zener diodes GR806 and GR807, serves also to clamp maximum V_{CE} of the transistor switches TS707...TS710.
Zener diode GR805 and resistor R815 serve to limit the load current, as the current supplied to the decoder-driver amounts to 7 mA max. (at $V_{QL} = 0$ V).

The voltage across C807 (+230 V) is used to supply LA701 ("-" indicator).

2. +15 V and +5 V source

This source is stabilized via voltage regulator IC801 which comprises a reference amplifier, a control amplifier and a current limiting circuit.

The +5 V source is derived from the +15 V source with zener diode GR801 and transistor TS801. R801 serves for current limitation for transistor TS801.

3. -19 V and -15 V source

This source is stabilized via voltage regulator IC802. The output current is limited by zener diode GR804 and series resistor R811.
The -15 V source is derived from the -19 V source with stabistor GR809.

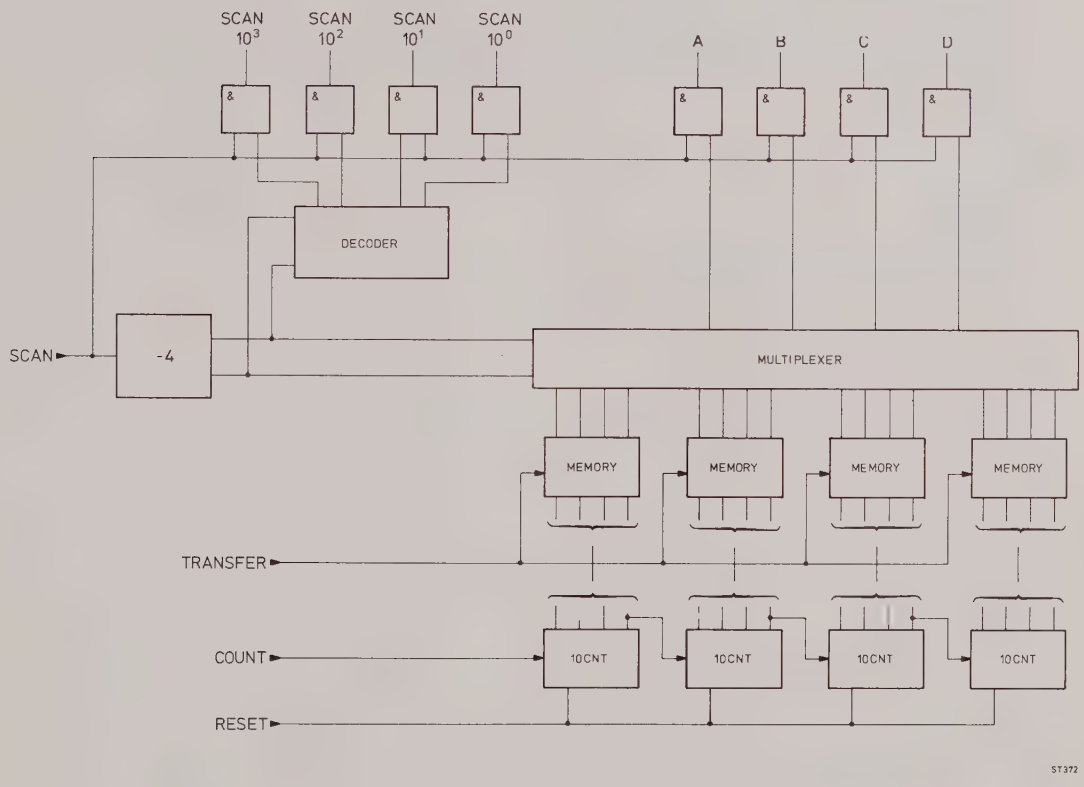


Fig. 21. 4 Decade counter

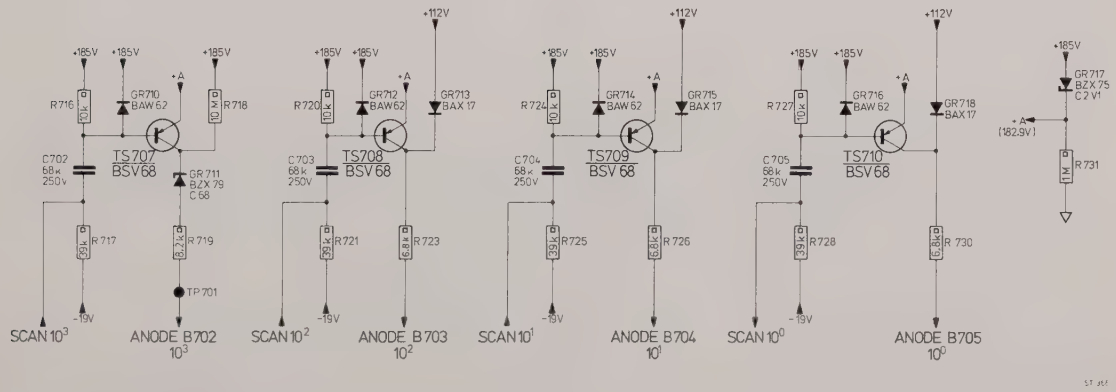


Fig. 22. Anode switches

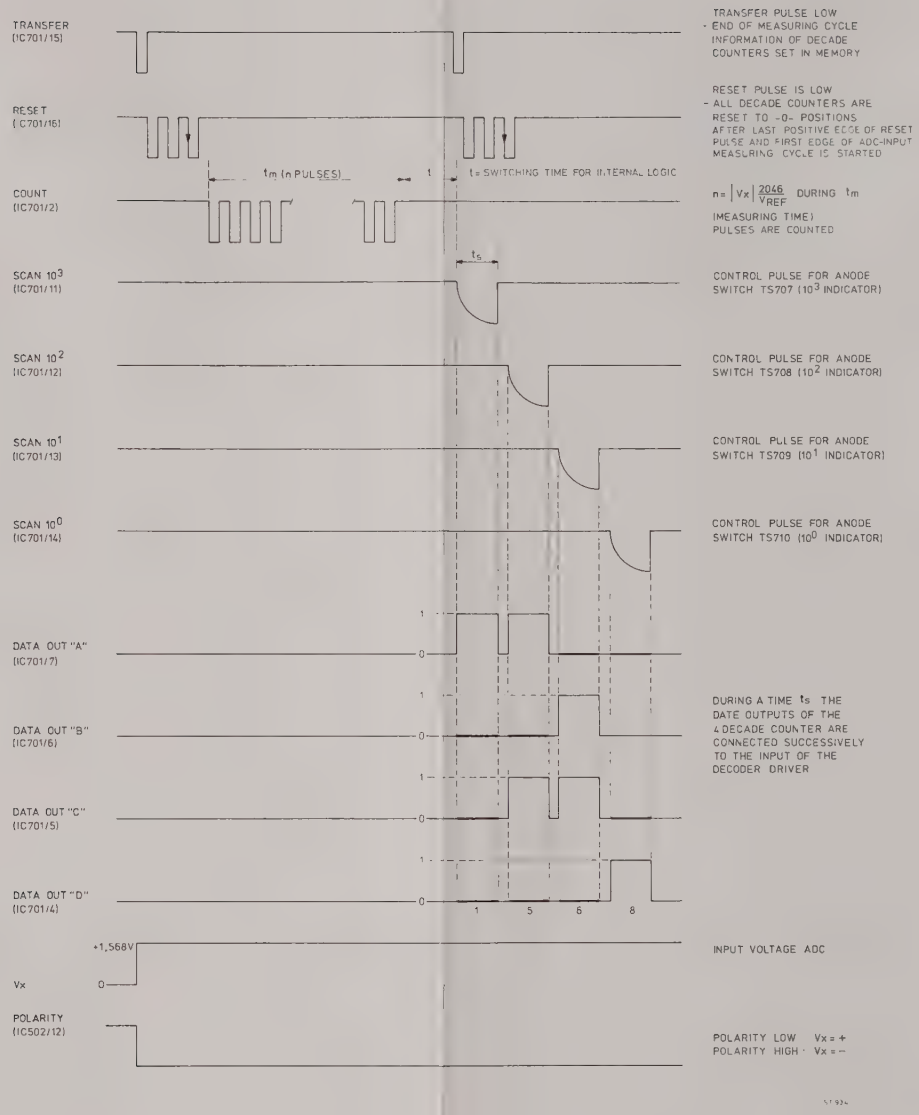

TRANSFER (IC701/15)
TRANSFER PULSE LOW - END OF MEASURING CYCLE INFORMATION OF DECADE COUNTERS SET IN MEMORY
RESET (IC701/16)
RESET PULSE IS LOW - ALL DECADE COUNTERS ARE RESET TO -0- POSITIONS AFTER LAST POSITIVE EDGE OF RESET PULSE AND FIRST EDGE OF ADC-INPUT MEASURING CYCLE IS STARTED
tm (n PULSES)
t
t = SWITCHING TIME FOR INTERNAL LOGIC
COUNT (IC701/2)
n = |Vx| 2046 / VREF DURING tm (MEASURING TIME) PULSES ARE COUNTED
ts
SCAN 10^3 (IC701/11)
CONTROL PULSE FOR ANODE SWITCH TS707 (10^3 INDICATOR)
SCAN 10^2 (IC701/12)
CONTROL PULSE FOR ANODE SWITCH TS708 (10^2 INDICATOR)
SCAN 10^1 (IC701/13)
CONTROL PULSE FOR ANODE SWITCH TS709 (10^1 INDICATOR)
SCAN 10^0 (IC701/14)
CONTROL PULSE FOR ANODE SWITCH TS710 (10^0 INDICATOR)
DATA OUT "A" (IC701/7)
DATA OUT "B" (IC701/6)
DATA OUT "C" (IC701/5)
DATA OUT "D" (IC701/4)
1
0
1 5 6 8
DURING A TIME ts THE DATE OUTPUTS OF THE 4 DECADE COUNTER ARE CONNECTED SUCCESSIVELY TO THE INPUT OF THE DECODER DRIVER
+1,568V
Vx
0
INPUT VOLTAGE ADC
POLARITY (IC502/12)
POLARITY LOW Vx = +
POLARITY HIGH Vx = -
ST934

Fig. 23. Sequence diagram

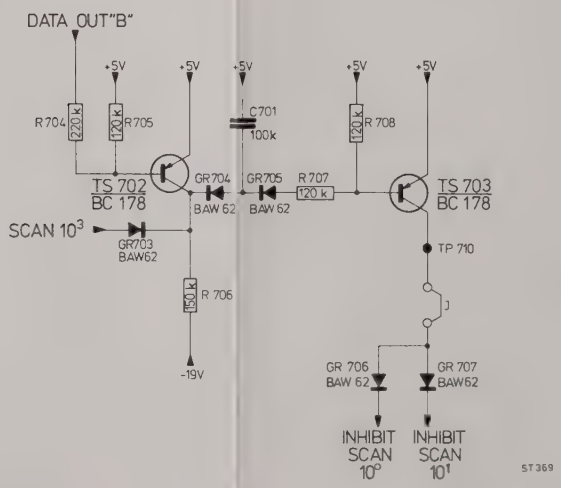


Fig. 24. Overrange detector

VIII. ACCESS

The opening of parts, or removal of covers, is likely to expose live conductors. The instrument should therefore be disconnected from all voltage sources before any opening of parts or removal of covers is started.
During and after dismantling, bear in mind that capacitors in the instrument may still be charged even if it has been separated from all voltage sources.

USE A WELL-FITTING CROSSHEAD SCREW-DRIVER TO DISMANTLE THE INSTRUMENT TO PREVENT THE CROSS-SLOTTED SCREWS FOR DAMAGE.

A. DISMANTLING

1. Top cover

   - Remove both screws "A" (Fig. 31).
   - Lift the cover at the rear and slide it backwards from the unit.

2. Bottom cover

   - Remove both screws "B" (Fig. 31).
   - Lift the cover at the rear and slide it backwards from the unit.

B. FUSES

1. Fuse VL1

   The mains supply is protected by fuse VL1 mounted inside on the rear plate (fig. 32, page 101).

2. Fuse VL101

   In the resistance circuit fuse VL101 will protect the zener current. If the current exceeds 125 mA, the fuse will blow.

3. Fuse VL103

   In the current circuit (via terminals I, BU4) a 6.3 A glass fuse has been incorporated to protect the shunt resistors R116-120.

C. ELECTRICAL COMPONENTS

If an electrical component (resistor, capacitor, transistor or integrated circuit) has been replaced by a new one, the relevant part of the circuit must be checked in accordance with chapter XI.
The next survey indicates roughly which sub-point(s) of chapter XI must be performed.

Part number	Adjust or check in accordance with
R102...R107 (Attenuator)	XI.D.4., XI.F.1. and XI.F.2.
R116...R120 (Shunts)	XI.G.
C101-C105 (a.c. attenuator)	XI.E.4. and XI.E.5.
Components starting with sequence number 2..	XI.D.1., XI.D.2. and XI.D.3.

Part number	Adjust or check in accordance with
Components starting with sequence number 3..	XI.E.1., XI.E.2. and XI.E.3.
Components starting with sequence number 4..	XI.F.1.
Components starting with sequence number 5..	XI.C.1., XI.C.2. and XI.C.3.
Components starting with sequence number 6..	XI.C.1., XI.C.2. and XI.C.3.

IX. MAINTENANCE AND SERVICE

Digital multimeter PM 2422A requires no maintenance because the instrument contains no components which are subject to wear.
However, to ensure reliable and faultless operation, the instrument should not be exposed to moisture, heat, corrosive vapours and excessive dust.

Service hints

If service work must be performed, the following points should be taken into account to avoid damage of the instrument.

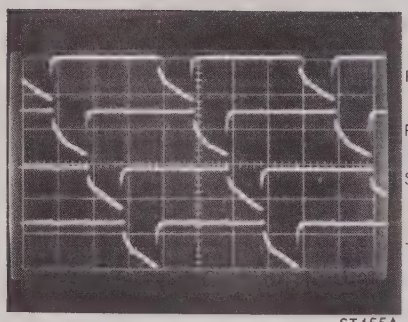
- In case of measurements on a switched-on instrument proceed carefully to avoid short-circuits by means of measuring clips or measuring hooks
- For soldering use absolutely acid-free soldering tin
- For all soldering work on the printed circuit boards, use a miniature soldering iron (35 W max.) with a thin-cleaner or a vacuum soldering iron.

Trouble shooting

On the printed wiring board test points are introduced at the component side as well as at the conductor side. The test points at the component side (Fig. 25) are especially made for service work, those at the conductor side for testing purposes in the factory. The latter can, of course, also be used for servicing (Fig. 26).
Furthermore, jumpers are introduced on the printed wiring board (Fig. 27); they can be used to interrupt circuits in order to test the functioning of the corresponding circuit.

General conditions:

- nominal mains voltage (220 V, 50 Hz)
- calibrated
- voltages with respect to circuit zero (terminal "0"), unless otherwise stated
- the data given represent the properties of an average instrument and may serve as a guide only
- voltages are measured with digital multimeter PM 2421
- oscillograms are recorded with oscilloscopes PM 3370 and PM 3250
- measure voltages and oscillograms with 10 MΩ input impedance.



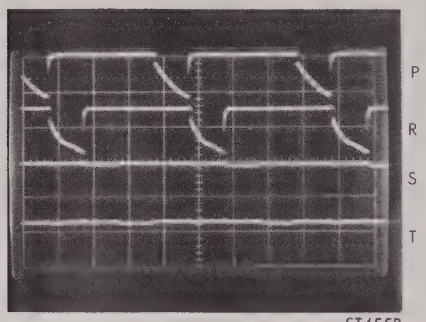
ST455A

I

P, R, S and T are the scanning outputs for controlling the anode switches
P = Scan 10^3_2
R = Scan 10^2_1
S = Scan 10^1_0
T = Scan 10^0

Oscilloscope settings
Amplitude : 10 V/cm
Time base : 2 msec/cm

Oscillograms apply for no overload condition.



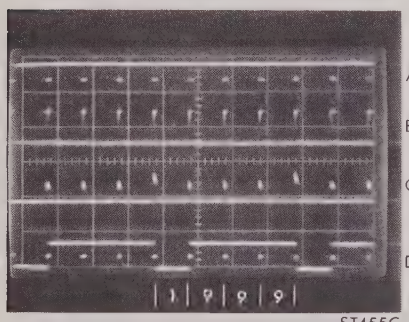
ST455B

II

P = Scan 10^3_2
R = Scan 10^2_1
S = Scan 10^1_0
T = Scan 10^0

Oscilloscope settings
Amplitude : 10 V/cm
Time base : 2 msec/cm

Oscillograms apply for overload condition.



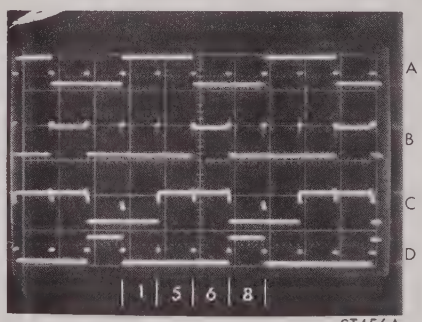
ST455C

III

A = Data out A (1)
B = Data out B (2)
C = Data out C (4)
D = Data out D (8)

Oscilloscope settings
Amplitude : 5 V/cm
Time base : 2 msec/cm

Oscillograms apply for display 1999.



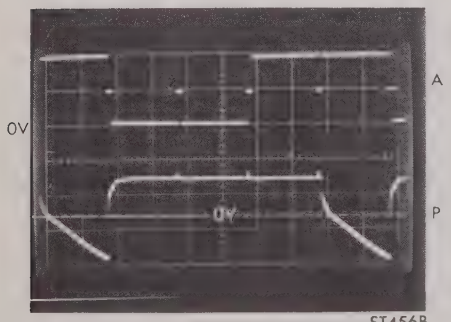
ST456A

IV

A = Data out 10^3_2
B = Data out 10^2_1
C = Data out 10^1_0
D = Data out 10^0

Oscilloscope settings
Amplitude : 5 V/cm
Time base : 2 msec/cm

Oscillograms apply for display 1568.



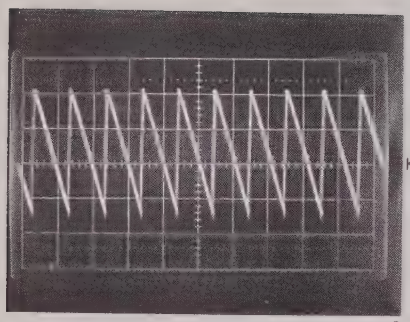
ST456B

V

A = Data out A
P = Scan 10^3

Oscilloscope settings
Amplitude A : 2 V/cm
Amplitude P : 5 V/cm
Time base : 1 msec/cm

Display 1568.

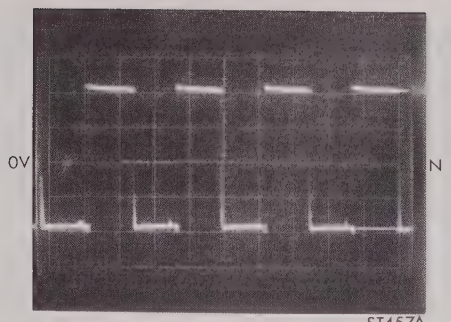


VI

Comparator output

Oscilloscope settings
Amplitude : 1 V/cm
Time base : 2 msec/cm

Input voltage ADC is 1.8 V

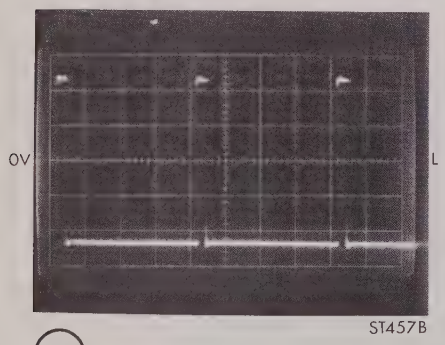


VII

Count

Oscilloscope settings
Amplitude : 2 V/cm
Time base : 1 msec/cm

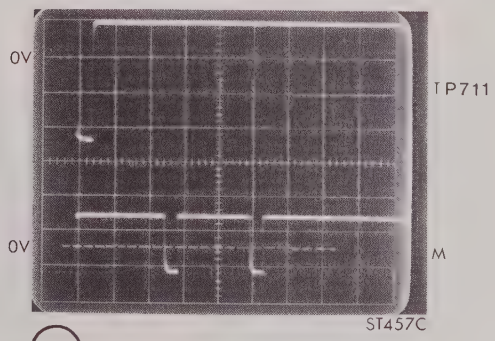
2 V at input of ADC



VIII

Scan in

Oscilloscope settings
Amplitude : 2 V/cm
Time base : 0.5 msec/cm



IX

TP711 = Transfer out
M = Reset

Oscilloscope settings
Amplitude : 5 V/cm
Time base : 50 μsec/cm

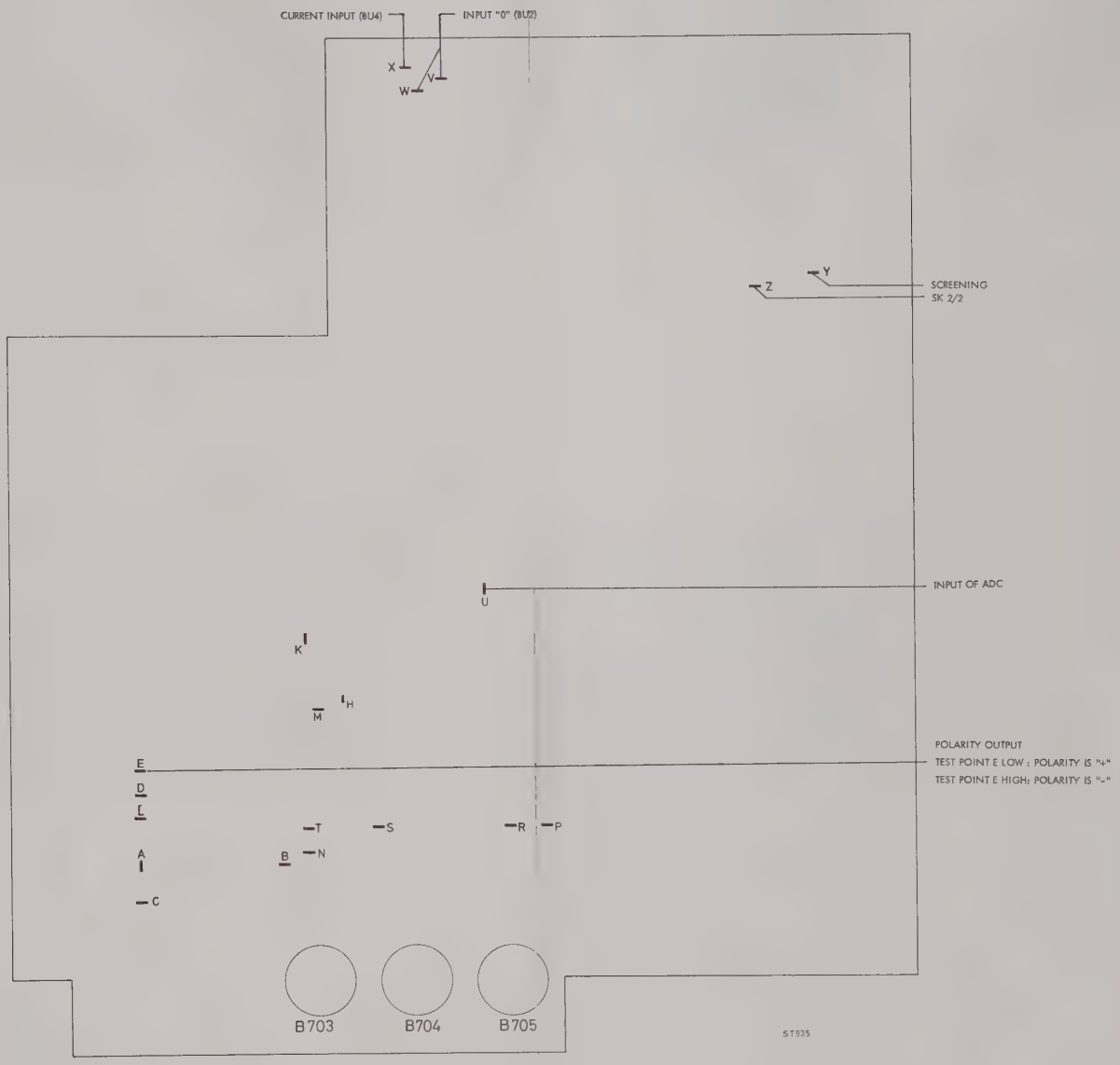
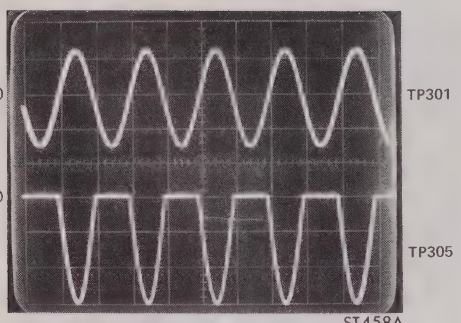


Fig. 25. Location of test points at component side of the printed wiring board.

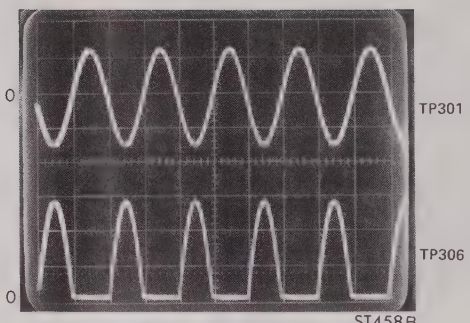


X

TP301 Input a.c.-to-d.c. converter
TP305 Output neg. rectifier

Oscilloscope settings
Amplitude : 2 V/cm
Time base : 0.5 msec/cm

Input voltage : 1.994 V
Frequency : 1 kHz

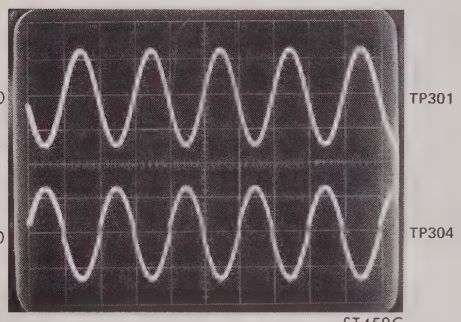


XI

TP301 Input a.c.-to-d.c. converter
TP306 Output pos. rectifier

Oscilloscope settings
Amplitude : 2 V/cm
Time base : 0.5 msec/cm

Input voltage : 1.994 V
Frequency : 1 kHz

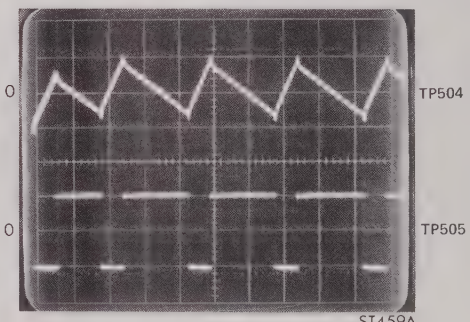


XII

TP301 Input voltage a.c.-to-d.c. converter
TP304 Output a.c.-to-d.c. converter

Oscilloscope settings
Amplitude:
TP301 2 V/cm
TP304 5 V/cm
Time base : 0.5 msec/cm

Input voltage: 1.994 V
Frequency : 1 kHz

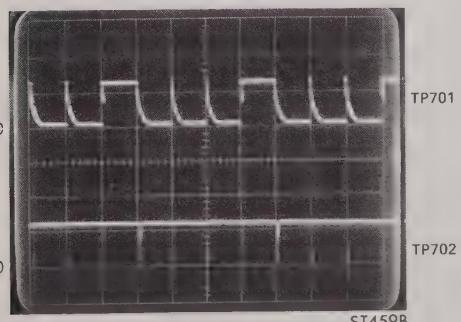


XIII

TP504 Output comparator
TP505 Chopped output reference

Oscilloscope settings
Amplitude : 2 V/cm
Time base : 0.2 msec/cm

Input voltage ADC : 1 V

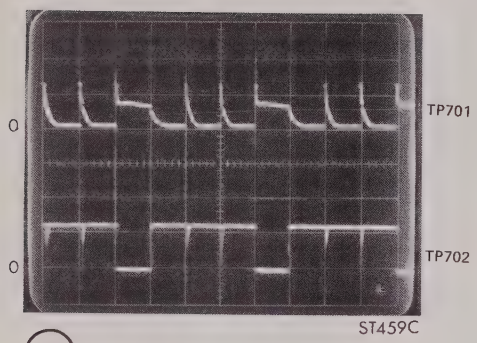


XIV

TP701 Anode LA702 (10^3 indicator)
TP702 Cathode LA702

Oscilloscope settings
Amplitude:
TP701 100 V/cm
TP702 50 V/cm
Time base : 2 msec/cm

Display 000

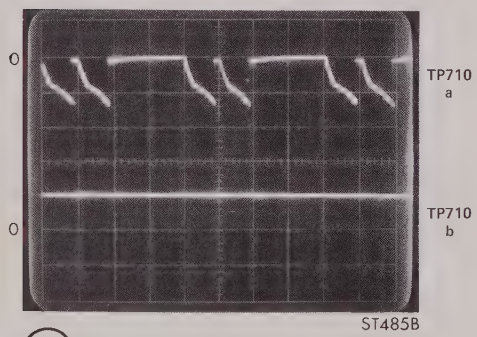


XV

TP701 Anode LA702 (10^3 indicator)
TP702 Cathode LA702

Oscilloscope settings
Amplitude:
TP701 100 V/cm
TP702 50 V/cm
Time base : 2 msec/cm

Display 1004



XVII

TP710 a: No overrange
TP710 b: Overrange

Oscilloscope settings
Amplitude : 5 V/cm
Time base : 2 msec/cm

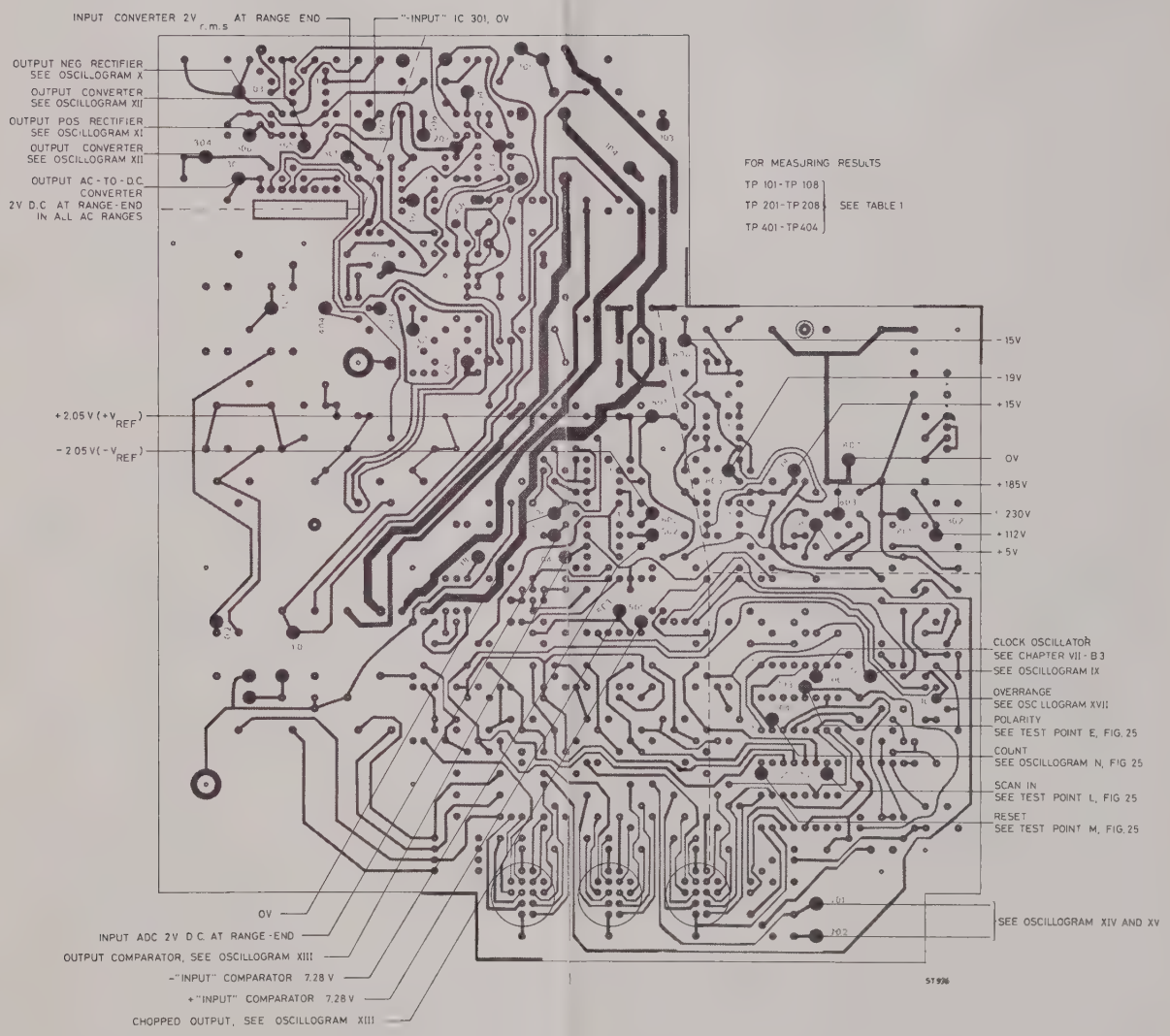


Fig. 26. Location of test points at conductor side of the printed wiring board.

TABLE 1

Test point	Function	Range	Measuring results: DC voltage	AC voltage	Resistors	Currents
101	V-R input	200 mV	value of	value of	-	-
		2 V	d.c. voltage	a.c. voltage	-	-
		20 V	supplied to	supplied to	-	-
		200 V	input	input	-	-
		1000 V			-	-
		200 Ω	-	-	199.9 mV	-
		2 kΩ	-	-	1.999 V	-
		20 kΩ	-	-	199.9 mV	-
		200 kΩ	-	-	1.999 V	-
		2 MΩ	-	-	199.9 mV	-
		20 MΩ	-	-	1.999 V	-
102	V-R input after fuse VL101	200 mV	value of	value of	-	-
		2 V	d.c. voltage	a.c. voltage	-	-
		20 V	supplied to	supplied to	-	-
		200 V	input	input	-	-
		1000 V			-	-
		200 Ω	-	-	199.9 mV	-
		2 kΩ	-	-	1.999 V	-
		20 kΩ	-	-	199.9 mV	-
		200 kΩ	-	-	1.999 V	-
		2 MΩ	-	-	199.9 mV	-
		20 MΩ	-	-	1.999 V	-
103	I Input	200 μA	-	-	-	0.2 V a.c. or d.c. + voltage loss across wiring and fuse at end-of-range
		2 mA	-	-	-	
		20 mA	-	-	-	
		200 mA	-	-	-	
		2 A	-	-	-	
104	I Input after fuse VL103	200 μA	-	-	-	0.2 V a.c. or d.c. + voltage loss across wiring at end-of-range values
		2 mA	-	-	-	
		20 mA	-	-	-	
		200 mA	-	-	-	
		2 A	-	-	-	
105	"0" Input		0 V	0 V	0 V	0 V
107	Voltage across shunts	200 μA	-	-	-	0.2 V a.c. or d.c. at end-of-range values
		2 mA	-	-	-	
		20 mA	-	-	-	
		200 mA	-	-	-	
		2 A	-	-	-	
201	Input 1x/10x amplifier	200 mV	199.9 mV	199.9 $mV_{r.m.s.}$	-	-
		2 V	1.999 V	1.999 $V_{r.m.s.}$	-	-
		20 V	199.9 mV	199.9 $mV_{r.m.s.}$	-	-
		200 V	1.999 V	1.999 $V_{r.m.s.}$	-	-
		1000 V	1 V	0.6 $V_{r.m.s.}$	-	-
		200 Ω	-	-	1.999 mV	-
		2 kΩ	-	-	1.999 V	-
		20 kΩ	-	-	1.999 mV	-
		200 kΩ	-	-	1.999 V	-
		2 MΩ	-	-	199.9 mV	-
		20 MΩ	-	-	1.999 V	-

Test point	Function	Range	Measuring results			
			DC voltage	AC voltage	Resistors	Currents
		200 µA	-	-	-	
		2 mA	-	-	-	
		20 mA	-	-	-	199.9 mV a.c. or d.c. at end of range
		200 mA	-	-	-	
		2 A	-	-		
202	Checking the functionning of the protection: - Supply + and -20 V d.c. to TP201 - The voltage at TP202 should be +8 V ± 2 V, respectively -8 V ± 2 V					
203	Drain TS203A and TS203B	2 V DC (TP201 = 0 V)	+8.2 V ± 5 %			
204 205	Source TS203A Source TS203B	at 0 V at the input (TP201) voltage at TP204 and TP205 > 0 < +1.5 V				
206	Feedback 1x/10x amplifier In position: gain 10x, the voltage at TP206 is $\frac{1}{10}$ of the voltage at TP207 In position: gain 1x, the voltage at TP206 is equal to the voltage at TP207					
207	Output 1x/10x amplifier		2 V d.c. at d.c. and resistance measurements 2 V a.c. at a.c. measurements 0 V at Vi = 0 (TP201 = 0 V)			} at end-of-range
208	1x/10x switch In position: gain 10x, TP208 = 0 V In position: gain 1x, the voltage at TP208 is equal to the voltage at TP207					
401	Output IC401	200 Ω	-	-	+1.20 V	-
		2 kΩ	-	-	+3.00 V	-
		20 kΩ	-	-	+1.20 V	-
		200 kΩ	-	-	+3.00 V	-
		2 MΩ	-	-	+1.20 V	-
		20 MΩ	-	-	+3.00 V	-
		input shorted	-	-	+1.00 V	-
402	- Input IC401	200 Ω	-	-	+199.9 mV	-
		2 kΩ	-	-	+1.999 V	-
		20 kΩ	-	-	199.9 mV	-
		200 kΩ	-	-	1.999 V	-
		2 MΩ	-	-	199.9 mV	-
		20 MΩ	-	-	1.999 V	-
403	Base TS401	-10 V in all ranges				
404	Collector TS401	same values as for TP402				

By means of the jumpers of Fig. 27 circuits may be interrupted for separate testing purposes. Interruption is done by removing the solder from the spot by means of a vacuum soldering iron.

A short survey of the jumpers follows:

Jumper		Function
A	Supply +230 V	Measuring of unloaded supply voltages It is recommended to interrupt always jumper A in order to prevent damaging of the circuits.
B	Supply +112 V	
C	Supply +185 V	
D	Supply + 15 V	
E	Supply + 5 V	
F	Supply - 19 V	
J	Overrange out	No detection of over-range indication. Maximum reading of 2046.
K	Comparator out	No special function
L	Chopped output of ADC	
N	Input from current source	Separation of the current source for Ω measurements and d.c. amplifier
P	Feed-back of 1x/10x amplifier	Measuring open loop gain of IC 201
R	A.C. feed-back IC 301	AC behaviour of the a.c. - to d.c. converter
S	D.C. feed-back IC 301	DC behaviour of the a.c. - to d.c. converter
T	Output current source	Functioning of the current source
U	Input ADC	Separation of analogue part and digital part

Fig. 27. Location of jumpers on the printed wiring board

X. CHECKING AND ADJUSTING SURVEY

The next table gives a survey of the adjustments and checking procedure of multimeter PM 2422A. For a complete adjustment adhere to the sequence of chapter XI.

Control element	Fig. 29	Checking or adjusting point	According to chapter XI sub-point
	-	Supply voltages +230 V, +185 V, +112 V, +15 V +5 V, -15 V and -19 V	A.2.
R515		Clock oscillator frequency	B
		ADC	
R505		Zero setting comparator	C.1.
R612		Zero setting ADC	C.2.
R603 R604		End-of-range calibration ADC (+)	C.3.
R611		End-of-range calibration ADC (-)	C.3.
		Direct voltage ranges	
R208		Zero setting	
R212		Offset DC amplifier	D.1.
R216		Gain 10x	D.2.
-	-	Linearity	D.3.
R102		Attenuator (20 V and 200 V range)	D.4.
		Alternating voltage ranges	
R302		End-of-range calibration (AC-to-DC converter)	E.1.
R304		Linearity (AC-to-DC converter)	E.1.
C209		Frequency response 1x/10x amplifier	E.2.
-	-	Linearity	E.3.
C101		Frequency independent attenuator	E.4.
C106		Frequency response	E.5.
		Resistance ranges	
R403		Adjustment current source	F.1.
R103		Calibration 2 MΩ and 20 MΩ ranges	F.2.
-	-	Direct current ranges	G

Required test equipment

To calibrate this measuring instrument only reference voltages and measuring equipment with the required accuracy should be applied. The test equipment and standards required for checking, adjusting or calibration are listed in the next table.

Test	Required performance	Recommended equipment
DC Calibration	Accuracy : at least ± 0.04 % Range : 10 mV ... 1000 V	DC standard e.g. PM 2480
AC Calibration	Accuracy : at least ± 0.08 % Voltage : 10 mV - 110 V Frequency: 30 Hz ... 25 kHz	AC standard e.g. HP745A
Resistance calibration	Resistance accuracy 50 Ω 190 Ω 200 Ω 600 Ω 1 kΩ 1.4 kΩ 1.9 kΩ 19 kΩ 190 kΩ 1.9 MΩ 19 MΩ at least 0.1 %	A series of standard resistors (e.g. metal film) or Guildline type 9330
Supply voltages		Multimeter e.g. PM 2421
Pulse form		Oscilloscope e.g. PM 3231
Clock frequency		Counter e.g. PM 6630

XI. CHECKING AND ADJUSTING

The tolerances stated in this chapter correspond to the factory data, which only apply to a newly re-adjusted instrument. Such data may differ from these given in chapter II, TECHNICAL DATA. Values without tolerances represent the properties of an average instrument and serve merely for reference.

A survey of the adjustments and adjusting elements is given in chapter X.

Perform calibration after a warming-up time of approximately 30 minutes.

Any adjustment, maintenance, and repair of an instrument which is opened whilst connected to the mains should be avoided as far as possible and, if inevitable, shall be only carried out by skilled personnel familiar with the risk of shock involved.

A. SUPPLY

1. Current consumption

The current consumption amounts to
- for 110 V mains : 250 mA max.
- for 220 V mains : 125 mA max.

2. Supply voltages

Check the supply voltage in accordance with the next table at nominal mains voltage

Supply	Value	Measuring point
+230 V	+230 V ± 15 V	TP801 (+) and terminal 0
+185 V	+185 V ± 10 V	TP803 (+) and terminal 0
+112 V	+112 V ± 8 V	TP802 (+) and terminal 0
+ 15 V	+ 15 V ± 0.9 V	TP804 (+) and terminal 0
+ 5 V	+ 5 V ± 0.3 V	TP805 (+) and terminal 0
- 15 V	- 15 V ± 1.4 V	TP808 (-) and terminal 0
- 19 V	- 19 V ± 1.2 V	TP806 (-) and terminal 0

B. CLOCK OSCILLATOR

- Connect an oscilloscope to test point L (SCAN)
- Check the pulse form (Fig. 28).

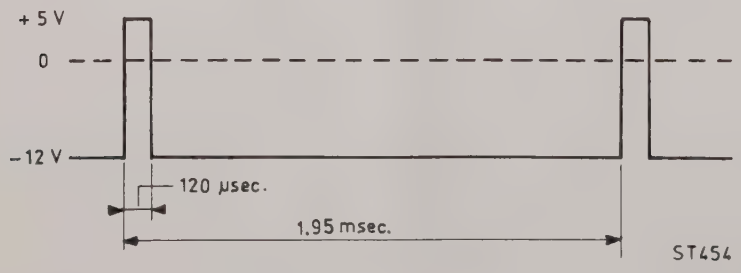


Fig. 28. Clock pulse

- Connect a counter (e.g. PM 6630) to test point L
- Adjust the frequency to 512 Hz ± 1 % with potentiometer R515 (the clock frequency will then be approximately 8.2 kHz).

C. ADC

1. Zero setting comparator

- Pull-out connector BU101 (by this the digital section is separated from the analog section)
- Connect pin U (input ADC) and jumper L (= TP505) with the zero level (e.g. terminal "0")
- Connect an oscilloscope to TP504 (output comparator).
  Oscilloscope settings: time base 0.5 msec/div.
  amplitude 5 V/div.
  Adjust potentiometer R505 as well as possible for zero level on the oscilloscope (within 1 div.)
- Remove the made connections

2. End-of-range calibration ADC

- Supply +1990 mV to test point U
- Adjust the reading to 1990 with potentiometer R604 (potentiometer CAL available at the rear)
- Supply -1990 mV to test point U.
- Adjust the reading to -1990 with potentiometer R611

3. Zero setting ADC

- Supply alternately + and -10 mV from a DC standard to test point U
- Adjust the reading to +010 and -010 with potentiometer R612.
  Repeat C2 and C3, after which BU101 should be connected.

D. CALIBRATING AND CHECKING THE DIRECT VOLTAGE RANGES

1. Calibration

- Interconnect terminals V-R (BU3) and 0 (BU2)
- Set range selector SK1 to 200 mV
- Depress button DC-R (SK2/1)
- Set potentiometer R208 (potentiometer ZERO available at the rear) to its mid-position
- Adjust the reading to 00.0 ± 3 digits with potentiometer R212.
  With potentiometer R208 (ZERO) the reading can be adjusted to 000.
- Set range selector SK1 to 2 V
- The reading should be .000. If not, the adjustment of the ADC is incorrect. Repeat sub-point C.
- Supply +1990 mV
- Adjust the reading to 1990 ± 0 digits with potentiometer R604 (potentiometer CAL available at the rear)
- Supply -1990 mV
- The reading should be -1990 ± 1 digit (if necessary, readjust with potentiometer R611).

2. Adjustment 1x/10x amplifier

- Set range selector SK1 to 200 mV
- Perform zero setting with potentiometer ZERO (R208)
- Supply +199.0 mV to inputs V-R (BU3) and 0 (BU2)
- Adjust the reading to 199.0 ± 0 digits with potentiometer R216
- Supply -199.0 mV
- The reading should be -199.0 ± 1 digit.

3. Checking the linearity

- Set range selector SK1 to position 200 mV
- Check the linearity of the instrument in accordance with the next table for positive as well as for negative voltages.

Supply to BU2-BU3	Reading
5 mV	05.0 ± 2 digits
10 mV	10.0 ± 2 digits
20 mV	20.0 ± 2 digits
40 mV	40.0 ± 2 digits
60 mV	60.0 ± 2 digits
80 mV	80.0 ± 2 digits
100 mV	100.0 ± 2 digits
120 mV	120.0 ± 2 digits
140 mV	140.0 ± 2 digits
160 mV	160.0 ± 2 digits
180 mV	180.0 ± 2 digits
199 mV	199.0 ± 2 digits

4. DC attenuator

Adjust or check the attenuator in accordance with the next table

Range selector to position	Supply to BU2-BU3	Reading	Adjust with
20 V	+ 19.9 V	19.90 ± 0 digits	R102
200 V	+199 V	199.0 ± 1 digit	-
1000 V	+990 V	990 ± 1 digit	-

E. CALIBRATING AND CHECKING THE ALTERNATING VOLTAGE RANGES

1. AC-to-DC converter

- Depress button AC (SK2/2).
- Adjust the converter in accordance with the next table

Range selector to position	Supply to BU2-BU3	Reading	Adjust with
200 mV	short-circuited	00.0 ± 5 digits	-
2 V	19 mV, 1 kHz	.019	R304
2 V	1900 mV, 1 kHz	1.900 ± 1 digit	R302
2 V	short-circuited	.000 ± 1 digit	
2 V	19 mV, 1 kHz	.019	R304
2 V	1900 mV, 1 kHz	1.900 ± 1 digit	R302

2. Frequency response AC-to-DC converter

- Adjust the converter in accordance with the next table

Range selector to position	Supply to BU2-BU3	Reading
200 mV	190 mV, 20 kHz	190.0 ± 5 digits
2 V	1.9 V, 20 kHz	1.900 ± 5 digits

If the reading in range 200 mV is too high and in range 2 V correct or too low, the value of capacitor C209 should be made higher.
If the reading in range 2 V is too high and in range 200 mV correct or too low, the value of capacitor C209 should be made smaller.

3. Checking the linearity

- Set range selector SK1 to position 200 mV
- Check the linearity of the instrument at a frequency of 1 kHz in accordance with the next table

Supply to BU2-BU3	Reading	Tolerance
5 mV	05.0	± 2 digits
20 mV	20.0	
40 mV	40.0	
60 mV	60.0	
80 mV	80.0	
100 mV	100.0	
120 mV	120.0	
140 mV	140.0	
160 mV	160.0	
180 mV	180.0	
190 mV	190.0	

4. Frequency independent attenuator

Adjust and check the attenuator in accordance with the next table

Range selector to position	Supply to BU2-BU3	Reading	Adjust with
200 mV	190 mV, 15 kHz	"X" (note this value)	-
20 V	19 V, 15 kHz	noted value "X"	C101
20 V	19 V, 150 Hz	19.00 ± 4 digits	-
20 V	19 V, 1.5 kHz	19.00 ± 4 digits	

5. Checking the frequency response

Check the frequency response in accordance with the next table

Range selector to position	Supply to BU2-BU3	Frequency	Reading	Tolerance
20 V	19 V	30 Hz	19.00	± 6 digits
		100 Hz	19.00	± 4 digits
		300 Hz	19.00	± 4 digits
		1 kHz	19.00	± 4 digits
		3 kHz	19.00	± 4 digits
		10 kHz	19.00	± 4 digits
		20 kHz	19.00	± 6 digits
		25 kHz	19.00	± 8 digits
200 V	109 V	30 Hz	109.0	± 6 digits
		100 Hz	109.0	± 4 digits
		300 Hz	109.0	± 4 digits
		1 kHz	109.0	± 4 digits
		3 kHz	109.0	± 4 digits
		10 kHz	109.0	± 4 digits
		20 kHz	109.0	± 4 digits
		25 kHz	109.0	± 8 digits
600 V AC	600 V	1 kHz	600	± 4 digits

If the deviation (downwards) is too large, add C106 parallel to C104 (ceramic capacitor 39 pF).

F. RESISTANCE RANGES

1. Adjustment

- Depress button DC/R (SK2/1)
- Set range selector SK1 to 200 kΩ
- The reading should be 0 (overload)
- Interconnect terminals V-R (BU3) and 0 (BU2)
- The reading should be 00.0 ± 1 digit
- Connect a resistor of 190 kΩ to terminals V-R (BU3) and 0 (BU2)
- Adjust the reading to 190.0 ± 1 digit with potentiometer R403
- Set range selector SK1 to position 2 MΩ
- Interconnect terminals V-R (BU3) and 0 (BU2)
- The reading should be .000 ± 1 digit (to be corrected with potentiometer ZERO at the rear)
- Connect a resistor of 1.9 MΩ to terminals V-R and 0
- Adjust the reading to 1.900 ± 1 digit with potentiometer R103
- Check the other ranges in accordance with the next table

Range selector to position	Connect to BU2-BU3	Reading	Tolerance
200 Ω	190 Ω	190.0	± 4 digits
20 kΩ	19 kΩ	19.00	± 4 digits
20 MΩ	19 MΩ	19.00	± 4 digits

2. Linearity

- Set range selector SK1 to position 2 kΩ
- Check the linearity in accordance with the table below

Connect to BU2-BU3	Reading	Tolerance
50 Ω	.050	± 2 digits
200 Ω	.200	± 3 digits
600 Ω	.600	± 3 digits
1000 Ω	1.000	± 3 digits
1400 Ω	1.400	± 3 digits
1900 Ω	1.600	± 4 digits

G. CHECKING THE DIRECT CURRENT RANGES

- Depress button DC/R (SK2/1).
- Check the direct current ranges in accordance with the next table

Range selector to position	Supply to BU4 a current of	Reading	Tolerance
200 μA	190 μA	190.0	
2 mA	1.9 mA	1.900	
20 mA	19 mA	19.00	± 6 digits
200 mA	190 mA	190.0	
2 A	1.9 A	1900	

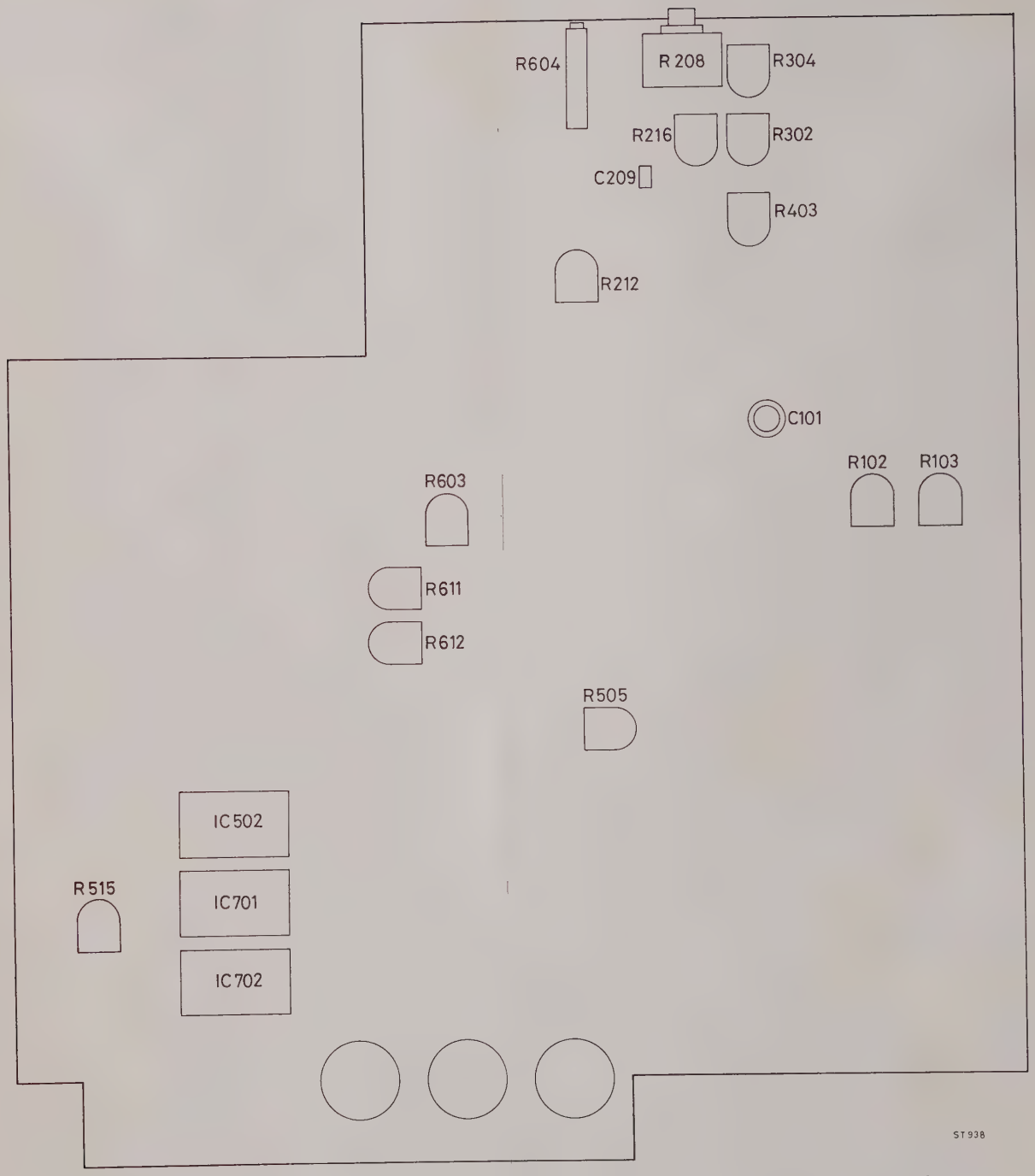


Fig. 29. Location of adjusting elements

XII. PARTS LIST

A. MECHANICAL

Item	Fig.	Qty.	Ordering number	Description
1	30	2	5322 447 94068	Top and bottom cover
2	30	1	5322 414 64039	Knob
3	30	1	5322 414 74019	Cap for knob
4	30	2	5322 535 74367	Spindle for handle
5	30	2	5322 498 74003	Cap for handle
6	30	1	5322 520 34139	Bearing bush, right
7	30	1	5322 520 34138	Bearing bush, left
8	30	4	5322 462 44121	Foot
9	30	4	5322 492 64338	Leaf spring
10	30	1	5322 498 54032	Handle
11	30	3	5322 414 14011	Knob for push button
12	30	4	5322 290 40011	Terminal BU1...BU4
13	30	1	5322 290 30001	Short-circuiting clip
14	30	1	5322 460 64002	Ornamental frame
15	30	1	5322 456 14031	Text plate
16	30	1	5322 459 24033	Window
17	31	2	5322 462 44175	Foot
18	31	1	5322 325 54029	Cable grommet
19	31	1	5322 321 14001	Mains cable
21	31	2	5322 532 64119	Guiding bush
22	32	1	5322 267 54041	8-pole contact block BU101
23	32	1	5322 273 84012	Switch SK1
24	32	1	5322 532 54209	Coppling piece
25	32	1	5322 535 94637	Extension spindle
26	32	3	5322 255 70145	Valve holder
27	32	1	5322 256 94046	Indicator housing
28	32	3	5322 255 44044	IC holder, 16 pin
29	32	2	5322 255 40079	Heat sink
30	32	1	5322 267 54038	8-pole contact socket BU102
31	32+33	2	5322 264 54006	Connector housing
32	32+33	13	5322 268 14013	Pin contact
33	32	1	5322 256 34021	Fuse holder
34	33	1	5322 276 10272	Mains switch SK3
35	33	1	5322 492 64337	Retaining spring
36	33	1	5322 535 94637	Extension spindle
37	33	1	5322 276 24016	Push-button switch SK2
38	6	1	5322 290 40077	Measuring terminal

x See chapter VIII.C

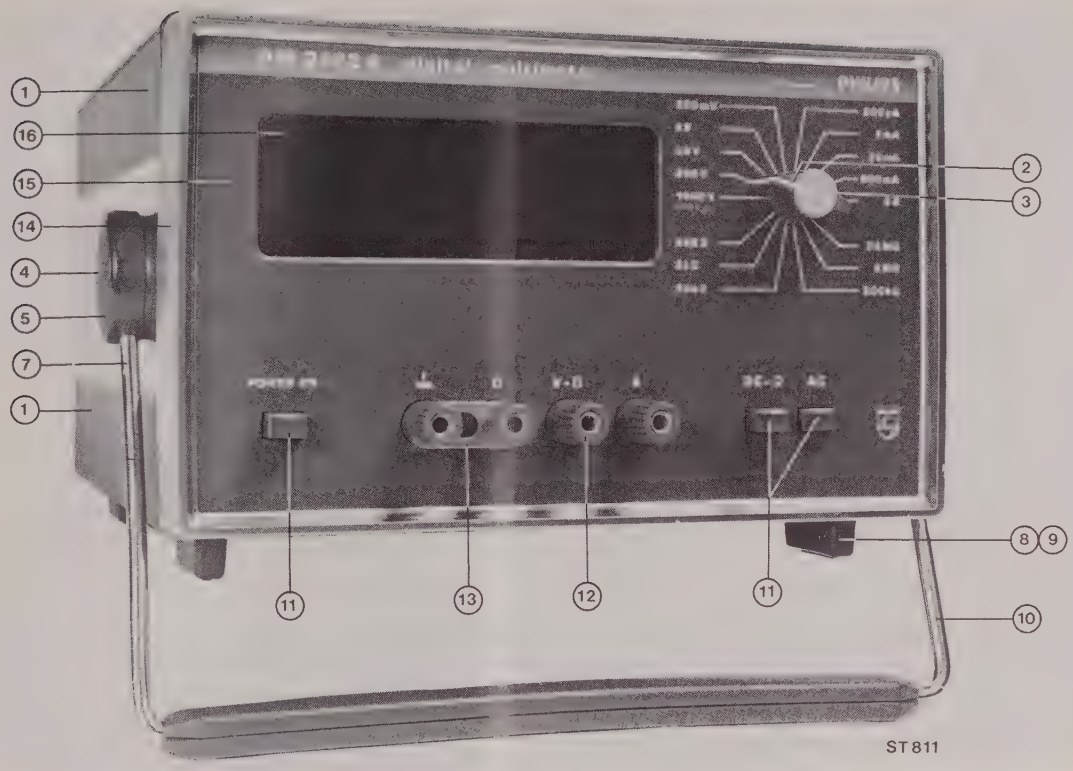


Fig. 30. Front view with indication of item numbers

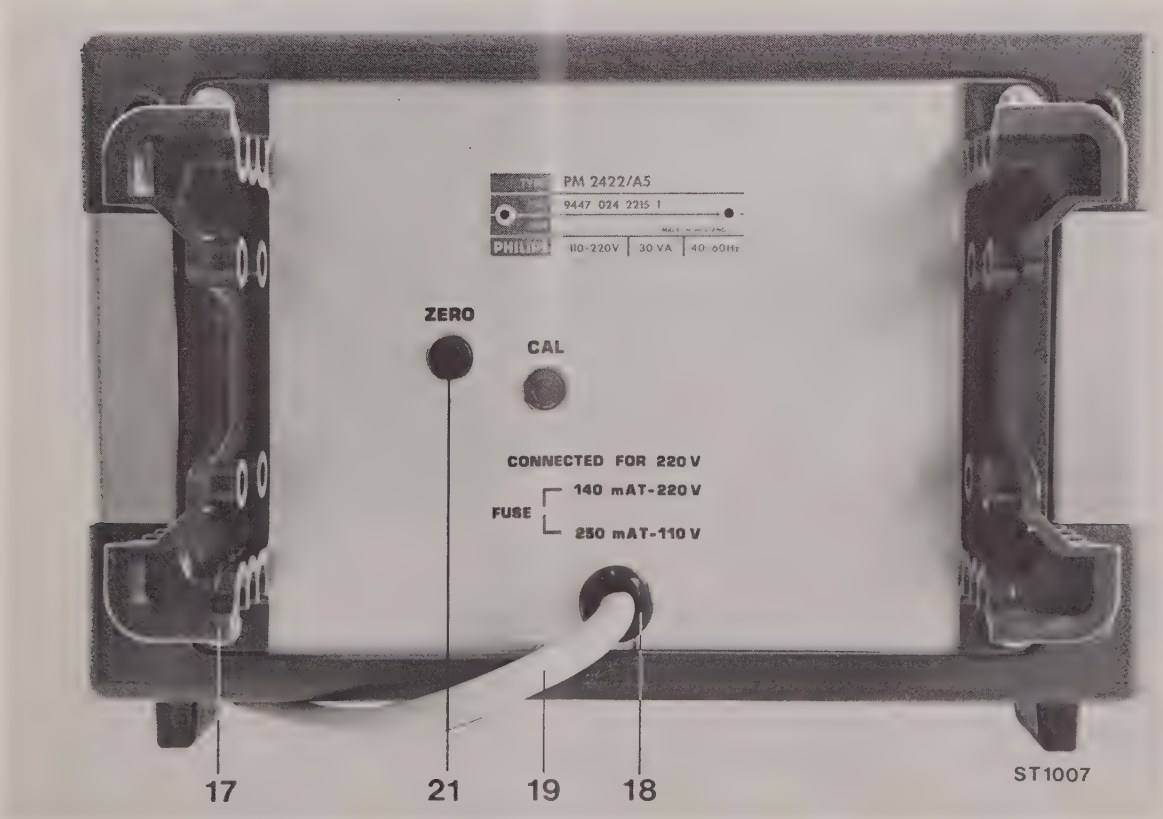


Fig. 31. Rear view with indication of item numbers

B. ELECTRICAL

This parts list does not contain multi-purpose and standard parts. These components are indicated in the circuit diagram by means of identification marks. The specification can be derived from the survey below.

Diese Ersatzteilliste enthält keine Universal- und Standard-Teile. Diese sind im jeweiligen Prinzipschaltbild mit Kennzeichnungen versehen. Die Spezifikation kann aus nachstehender Übersicht abgeleitet werden.

In deze stuklijst zijn geen universele en standaardonderdelen opgenomen. Deze componenten zijn in het principeschema met een merkteken aangegeven. De specificatie van deze merktekens is hieronder vermeld.

La présente liste ne contient pas des pièces universelles et standard. Celles-ci ont été repérées dans le schéma de principe. Leurs specifications sont indiquées ci-dessous.

Esta lista de componentes no comprende componentes universales ni standard. Estos componentes están provistos en el esquema de principio de una marca. El significado de estas marcas se indica a continuación.

Carbon resistor E24 series
Kohleschichtwiderstand, Reihe E24
Koolweerstand E24 reeks
Résistance au carbone, série E24
Resistencia de carbón, serie E24
0,125 W 5%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
1 W ≦ 2,2 MΩ, 5%
> 2,2 MΩ, 10%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
0,25 W ≦ 1 MΩ, 5%
> 1 MΩ, 10%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
2 W 5%

Carbon resistor E24 series
Kohleschichtwiderstand, Reihe E24
Koolweerstand E24 reeks
Résistance au carbone, série E24
Resistencia de carbón, serie E24
0,5 W ≦ 5 MΩ, 1%
> 5 ≦ 10 MΩ, 2%
> 10 MΩ, 5%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
0,4 – 1,8 W 0,5%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
0,5 W ≦ 1,5MΩ, 5%
> 1,5MΩ, 10%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
5,5 W ≦ 200 Ω, 10%
> 200 Ω, 5%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
10 W 5%

Tubular ceramic capacitor
Rohrkondensator
Keramische kondensator, buistype
Condensateur céramique tubulaire
Condensador cerámico tubular
500 V

Polyester capacitor
Polyesterkondensator
Polyesterkondensator
Condensateur au polyester
Condensador polyester
400 V

Tubular ceramic capacitor
Rohrkondensator
Keramische kondensator, buistype
Condensateur céramique tubulaire
Condensador cerámico tubular
700 V

Flat-foil polyester capacitor
Miniatur-Polyesterkondensator (flach)
Platte miniatuur polyesterkondensator
Condensateur au polyester, type plat
Condensador polyester, tipo de placas planas
250 V

Ceramic capacitor, "pin-up"
Keramikkondensator "Pin-up" (Perltyp)
Keramische kondensator "Pin-up" type
Condensateur céramique, type perle
Condensador cerámico, versión "colgable"
500 V

Paper capacitor
Papierkondensator
Papierkondensator
Condensateur au papier
Condensador de papel
1000 V

"Microplate" ceramic capacitor
Miniatur-Scheibenkondensator
"Microplate" keramische kondensator
Condensateur céramique "microplate"
Condensador cerámico "microplaca"
30 V

Wire-wound trimmer
Drahttrimmer
Draadgewonden trimmer
Trimmer à fil
Trimmer bobinado

Mica capacitor
Glimmerkondensator
Micakondensator
Condensateur au mica
Condensador de mica
500 V

Tubular ceramic trimmer
Rohrtrimmer
Buisvormige keramische trimmer
Trimmer céramique tubulaire
Trimmer cerámico tubular

For multi-purpose and standard parts, please see PHILIPS' Service Catalogue.
Für die Universal- und Standard-Teile siehe den PHILIPS Service-Katalog.
Voor universele en standaardonderdelen raadplege men de PHILIPS Service Catalogus.
Pour les pièces universelles et standard veuillez consulter le Catalogue Service PHILIPS.
Para piezas universales y standard consulte el Catálogo de Servicio PHILIPS.

Resistors

No.	Ordering number	Value	%	Series	Description
R102	5322 101 14045	330 kΩ	20	0.5 W	Potentiometer
R103	5322 101 14045	330 kΩ	20	0.5 W	Potentiometer
R104	5322 116 54379	9.76 MΩ	1		Metal film
R105	5322 116 51019	90 kΩ	0.1	MR54C	Metal film
R106	5322 116 50943	9 kΩ	0.1	MR34C	Metal film
R107	5322 116 54381	996 Ω	0.1	MR34C	Metal film
R108	5322 112 20076	68 Ω	5	4.2 W	Wire-wound
R110	5322 116 50525	14.7 kΩ	1	MR25	Metal film
R112	5322 112 20052	8.2 Ω	10	4.2 W	Wire-wound
R113	5322 112 20052	8.2 Ω	10	4.2 W	Wire-wound
R114	5322 112 20052	8.2 Ω	10	4.2 W	Wire-wound
R115	5322 112 20052	8.2 Ω	10	4.2 W	Wire-wound
R116	5322 115 80099	0.1+0.9 Ω	0.25		Wire-wound
R117	5322 113 24095	4.5 Ω	0.25	0.6 W	Wire-wound
R118	5322 113 24095	4.5 Ω	0.25	0.6 W	Wire-wound
R119	5322 113 24096	90 Ω	0.25	0.6 W	Wire-wound
R120	5322 113 24097	900 Ω	0.25	0.6 W	Wire-wound
R201	5322 116 51059	34.8 kΩ	1	MR25	Metal film
R204	5322 116 50451	21.5 kΩ	1	MR25	Metal film
R205	5322 116 50524	3.01 kΩ	1	MR25	Metal film
R206	5322 116 54156	154 kΩ	1	MR30	Metal film
R207	5322 116 54156	154 kΩ	1	MR30	Metal film
R208	5322 101 20277	2.2 kΩ	20	0.1 W	Potentiometer
R212	5322 100 10152	22 kΩ	20	0.5 W	Potentiometer
R214	5322 116 54078	10.5 kΩ	0.5	MR24C	Metal film
R215	5322 116 54141	1.15 kΩ	0.5	MR24C	Metal film
R216	5322 100 10054	47 Ω	20	0.5 W	Potentiometer
R301	5322 116 50631	4.53 kΩ	1	MR25	Metal film
R302	5322 100 10124	220 Ω	20	0.5 W	Potentiometer
R304	5322 100 10154	4.7 MΩ	20	0.1 W	Potentiometer
R308	5322 116 50915	9.53 kΩ	1	MR25	Metal film
R309	5322 116 50915	9.53 kΩ	1	MR25	Metal film
R401	5322 116 50747	1 kΩ	0.5	MR24C	Metal film
R402	5322 116 54595	5.11 kΩ	1	MR25	Metal film
R403	5322 101 14046	680 Ω	20	0.5 W	Potentiometer
R404	5322 116 50855	4.02 kΩ	1	MR25	Metal film
R503	5322 116 50406	86.6 kΩ	1	MR25	Metal film
R504	5322 116 50406	86.6 kΩ	1	MR25	Metal film
R505	5322 100 10124	220 Ω	20	0.5 W	Potentiometer
R507	5322 116 50559	27.4 kΩ	1	MR25	Metal film
R515	4822 100 10052	100 kΩ	1	0.1 W	Potentiometer
R601	5322 116 50765	909 Ω	1	MR25	Metal film
R602	5322 116 50509	4.87 kΩ	1	MR25	Metal film
R603	5322 100 10137	470 Ω	20	0.5 W	Potentiometer
R604	5322 103 10047	100 Ω	20	0.5 W	Potentiometer

No.	Ordering number	Value	%	Series	Description
R605	5322 116 50379	1.43 kΩ	1	MR24	Metal film
R607	5322 116 54058	2.49 kΩ	0.1	MR24C	Metal film
R608	5322 116 54051	1.05 kΩ	0.1	MR24C	Metal film
R609	5322 116 54058	2.49 kΩ	0.1	MR24C	Metal film
R610	5322 116 50749	1.4 kΩ	1	MR25	Metal film
R611	5322 100 10125	10 kΩ	20	0.5 W	Potentiometer
R612	5322 100 10114	4.7 kΩ	20	0.5 W	Potentiometer
R733	5322 116 50557	46.4 kΩ	1	MR25	Metal film
R734	5322 116 50557	46.4 kΩ	1	MR25	Metal film
R735	5322 116 50557	46.4 kΩ	1	MR25	Metal film
R736	5322 116 50557	46.4 kΩ	1	MR25	Metal film
R803	5322 116 50458	7.87 kΩ	1	MR25	Metal film
R804	5322 116 50945	7.15 kΩ	1	MR25	Metal film
R805	5322 116 54239	5.36 Ω	1	MR25	Metal film
R806	5322 116 54221	3.65 kΩ	1	MR25	Metal film
R807	5322 116 50524	3.01 kΩ	1	MR25	Metal film
R808	5322 116 50524	3.01 kΩ	1	MR25	Metal film
R809	5322 116 50522	13 kΩ	1	MR25	Metal film
R810	5322 116 50524	3.01 kΩ	1	MR25	Metal film
R811	5322 116 50578	78.7 Ω	1	MR25	Metal film
R813	5322 116 50976	56.2 kΩ	1	MR25	Metal film
R814	5322 116 50576	95.3 kΩ	1	MR25	Metal film
R815	5322 116 54136	681 Ω	1	MR25	Metal film

Capacitors

No.	Ordering number	Value	%	V	Description
C1	5322 121 40149	100 nF	10	630	Polyester
C2	5322 122 14003	1 nF	20	400	Ceramic
C101	5322 125 64003	9 pF		500	Trimmer
C102	5322 122 34032	39 pF	2	500	Ceramic
C103	4822 122 31205	47 pF	2	500	Ceramic
C104	5322 120 64117	2.4 nF	1	500	Polyester
C105	5322 121 50287	22 nF	1	63	Polyester
C106	4822 120 11069	35 pF	5	500	Ceramic
C201	4822 122 31174	2.7 nF	10	500	Ceramic
C202	4822 122 31174	2.7 nF	10	500	Ceramic
C203	4822 121 40045	22 nF		250	Polyester
C205	4822 122 30128	4.7 nF	10	100	Ceramic
C206	4822 122 31167	2.2 nF	10	100	Ceramic
C207	4822 122 30043	10 nF	10	100	Ceramic
C208	4822 122 30043	10 nF	10	100	Ceramic
C209	4822 122 30008	47 pF	2	63	Ceramic
C301	4822 122 30008	47 pF	2	63	Ceramic
C302	4822 122 30002	150 pF	2	63	Ceramic
C303	4822 122 31049	6.2 pF		100	Ceramic
C304	4822 122 30043	10 nF	10	100	Ceramic
C305	4822 122 30043	10 nF	10	100	Ceramic
C306	4822 122 30004	5.6 pF		63	Ceramic

No.	Ordering number	Value		%	V	Description
C307	5322 121 40233	680	nF	10	100	Polyester
C308	5322 121 40283	3.3	µF	10	100	Polyester
C309	5322 121 40197	1	µF	10	100	Polyester
C501	5322 121 40175	470	nF	10	100	Polyester
C502	5322 121 40323	100	nF	10	100	Polyester
C503	4822 121 40231	150	nF	10	100	Polyester
C504	5322 122 30103	22	nF		40	Ceramic
C505	4822 122 30021	100	pF	2	63	Ceramic
C506	4822 122 31175	1	nF	10	100	Ceramic
C701	5322 121 40323	100	nF	10	100	Polyester
C702	4822 121 40057	68	nF	10	250	Polyester
C703	4822 121 40057	68	nF	10	250	Polyester
C704	4822 121 40057	68	nF	10	250	Polyester
C705	4822 121 40057	68	nF	10	250	Polyester
C709	5322 121 40323	100	nF	10	100	Polyester
C710	5322 121 40323	100	nF	10	100	Polyester
C711	5322 121 40323	100	nF	10	100	Polyester
C801	4822 124 20399	220	µF		40	Electrolytic
C802	4822 122 30021	100	pF	2	63	Ceramic
C803	4822 124 20362	22	µF		25	Electrolytic
C804	4822 124 20399	220	µF		40	Electrolytic
C805	4822 122 31177	470	pF	10	100	Ceramic
C806	4822 124 20362	22	µF		25	Electrolytic
C807	4822 124 20436	6.4	µF		300	Electrolytic
C808	4822 124 20362	22	µF		25	Electrolytic

Miscellaneous

Item	Ordering number	Description
T1	5322 146 24053	Mains transformer
VL1	5322 253 30008	Mains fuse 110 mA (220 V mains)
	4822 253 30013	Mains fuse 250 mA (110 V mains)
VL101	4822 253 20007	Fuse 125 mA
VL102	5322 252 60019	Spark gap
VL103	5322 253 20028	Fuse 6.3 A
L1, L2	5322 158 14036	HF Choke
LA701	5322 134 24013	Neon lamp GL14
LA702	5322 134 20057	Neon lamp
B703, B704, B705	5322 131 94002	Indicator ZM1005
	PM 9260	Set measuring leads

Transistors

Type	Ordering number	Qty.	Item
BC107	5322 130 40357	3	TS201, TS202, TS801
BFQ12	5322 130 44248	1	TS203,
BFW11	5322 130 40408	1	TS204
BCY56	5322 130 40325	2	TS401, TS502
BFQ15	5322 130 44409	1	TS501
BRY39	5322 130 40482	1	TS503
BC178	5322 130 40355	3	TS601, TS703, TS704
BF338	5322 130 44108	3	TS701, TS803, TS804
BSV68	5322 130 44058	4	TS707, TS708, TS709, TS710
2N2905A	5322 130 40468	1	TS802

Diodes

Type	Ordering number	Qty.	Item
BYX72-500	5322 130 34388	4	GR101, GR102, GR103, GR104
BZX70-C12	5322 130 30753	2	GR105, GR106
BZX79-C8V2	5322 130 34119	1	GR201
BZX79-C5V6	5322 130 30759	2	GR202/203
BAV10	5322 130 30594	2	GR301, GR302
BZX79-B5V1	5322 130 34223	1	GR402
BAW62	5322 130 30613	15	GR501, GR503, GR701, GR702, GR703, GR704, GR705, GR706, GR707, GR708, GR709, GR710, GR712, GR714, GR716
BZX79-C5V1	5322 130 30767	2	GR502, GR601
BZV11	5322 130 34294	1	GR602
BZX79-C68	5322 130 34234	1	GR711
BAX17	5322 130 30605	3	GR713, GR715, GR718
BZX75-C2V1	5322 130 34049	1	GR717
BZX79-B5V6	5322 130 34173	1	GR801
BY164	5322 130 30414	1	GR802
BZX79-C6V2	5322 130 30766	1	GR202, GR203, GR803
BZX79-C5V6	5322 130 30759	2	GR804, GR805
BZX61-C56	5322 130 30566	2	GR806, GR807
BY179	5322 130 30521	1	GR808
BZX75-C3V6	5322 130 30765	1	GR809

Integrated circuits

Type	Ordering number	Qty.	Item
ULN2139D	5322 209 84333	1	IC201
U9T7101392	5322 209 84691	1	IC301
TBA221B	5322 209 84486	3	IC401, IC501, IC601
FEY101B-S1	5322 209 84496	1	IC502
FEJ271B	5322 209 84336	1	IC701
SN74141AN	5322 209 84138	1	IC702
TBA281	5322 209 80245	2	IC801, IC802

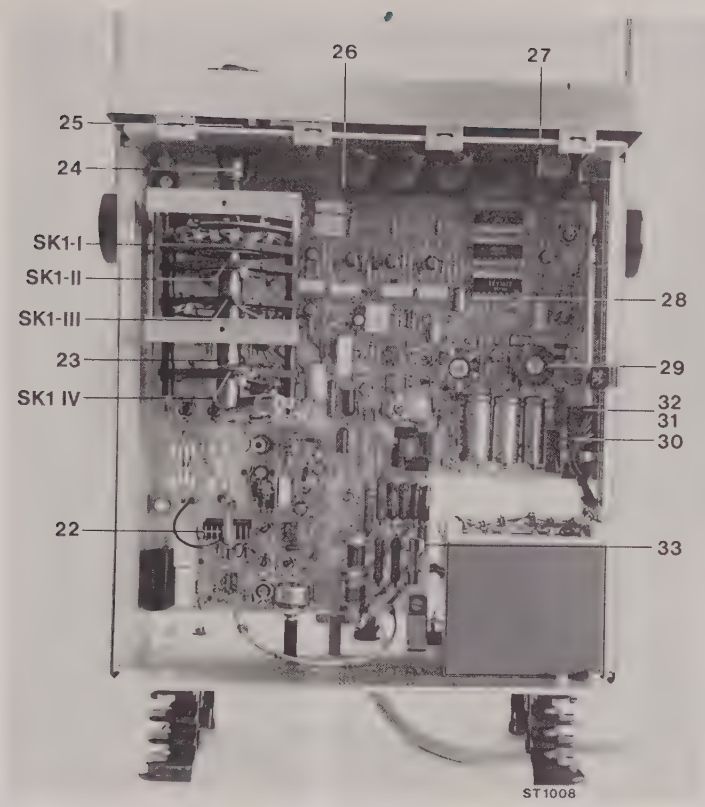


Fig. 32. Top view

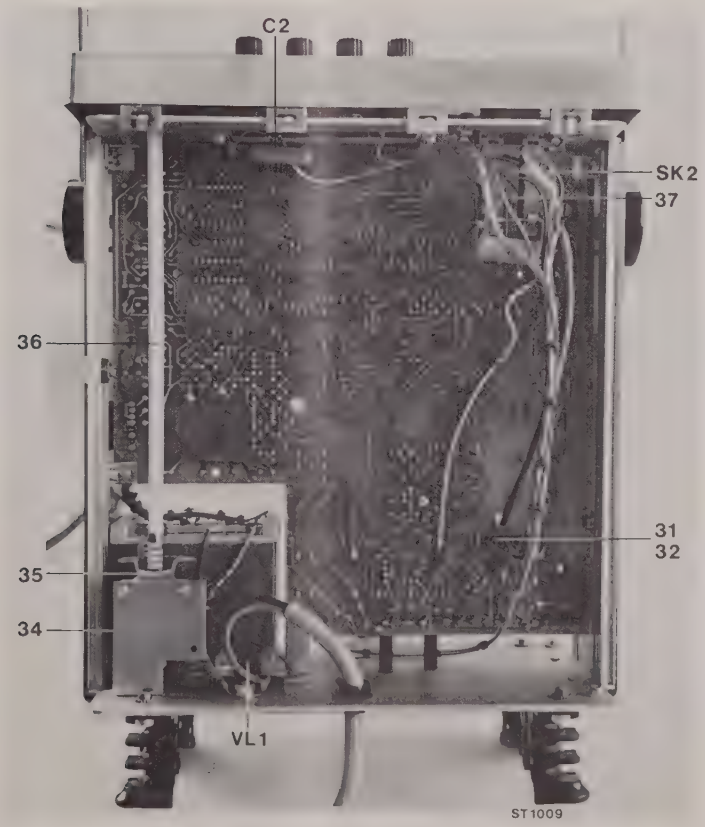


Fig. 33. Bottom view

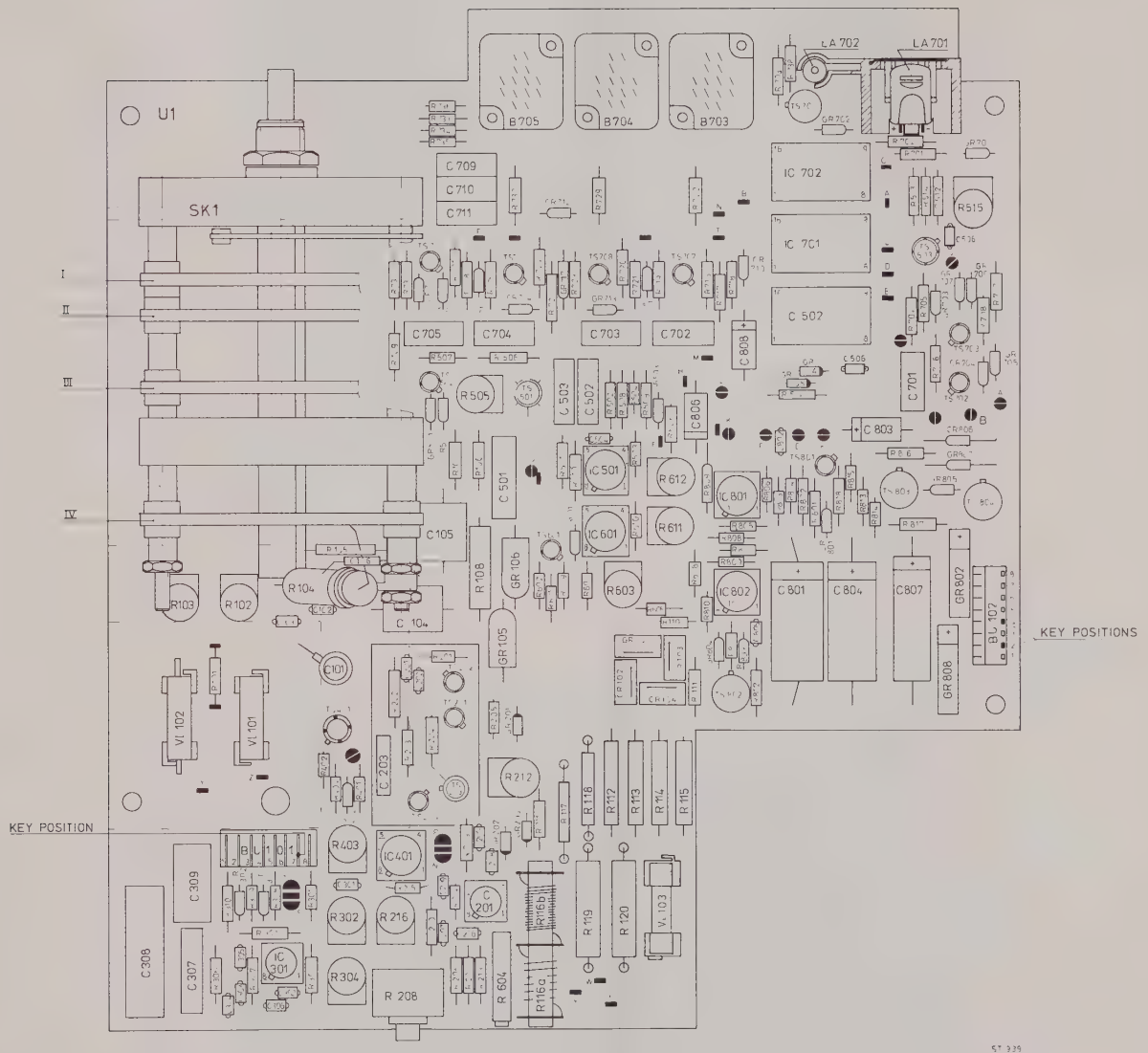


Fig. 34. Printed wiring board U 1

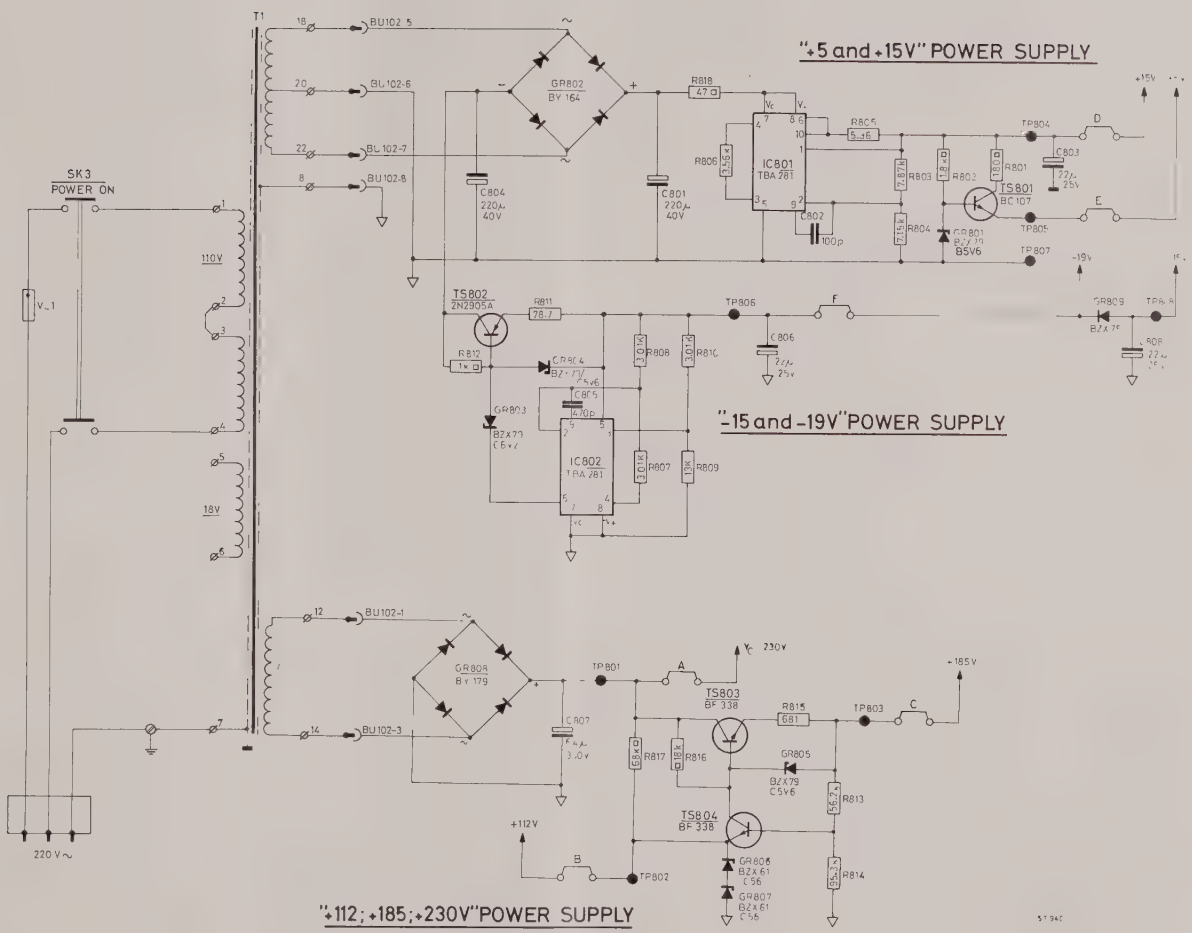
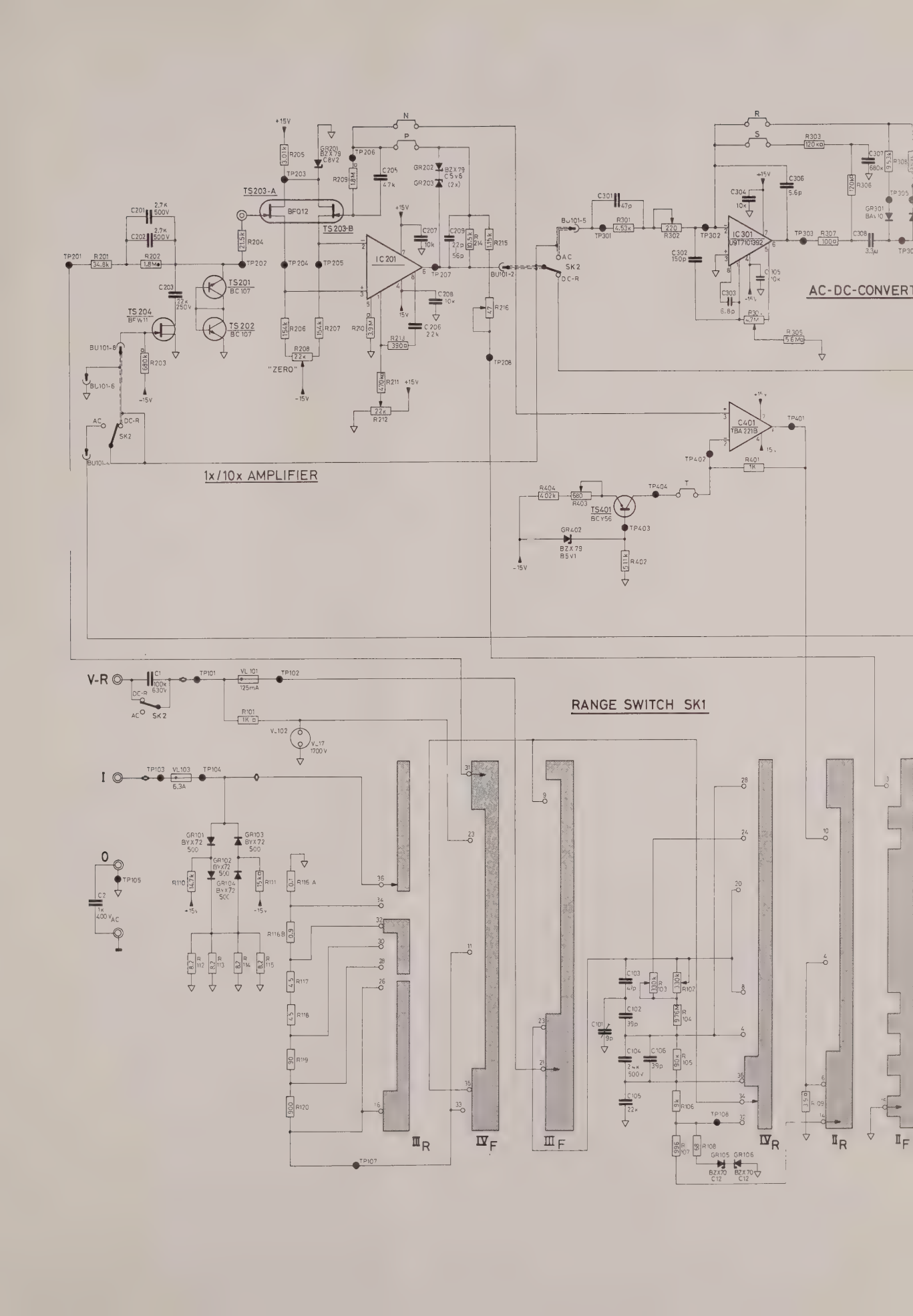
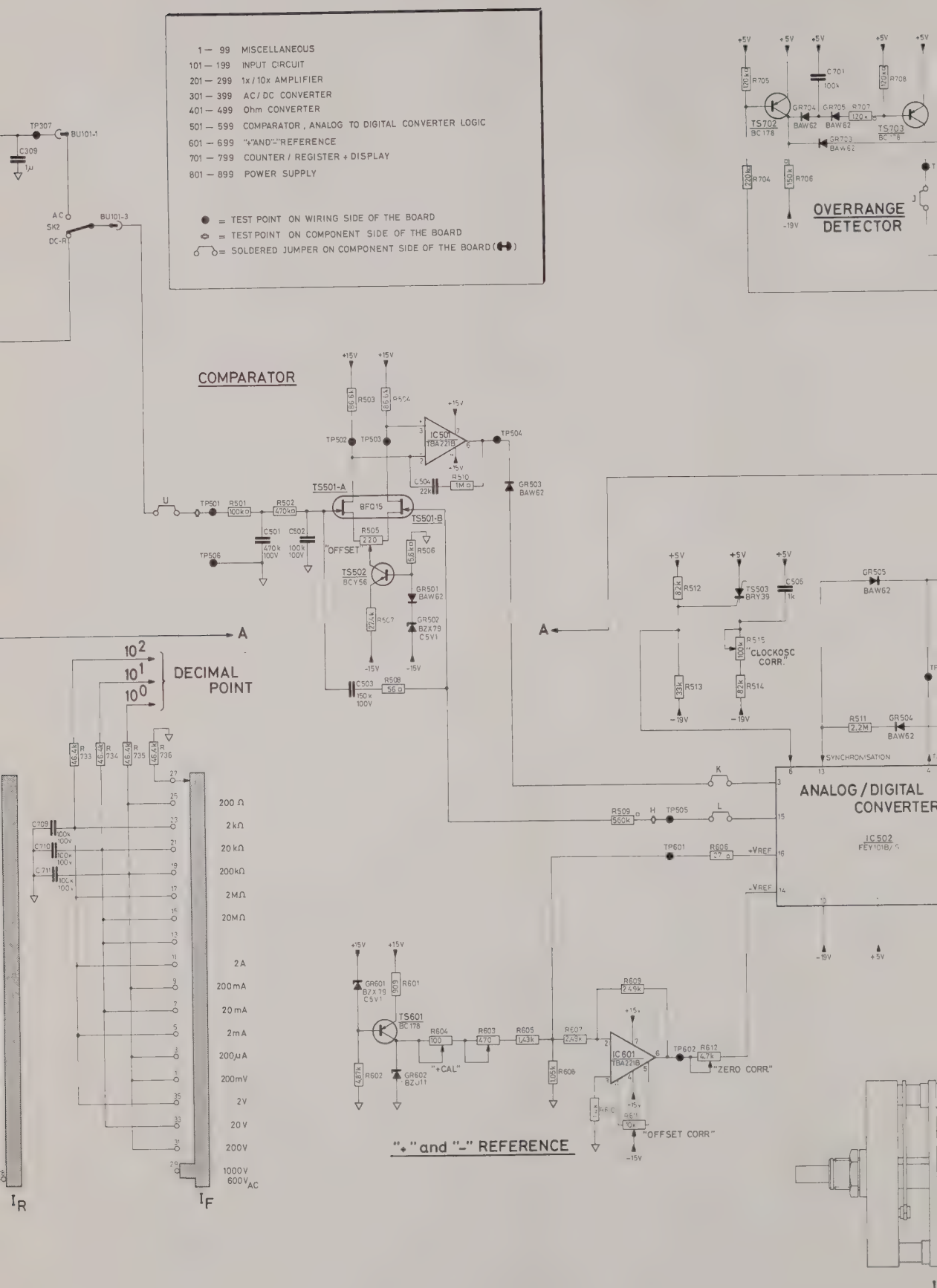


Fig. 35. Circuit diagram supply section PM 2422 A


1x/10x AMPLIFIER
AC-DC-CONVERT
RANGE SWITCH SK1
IC 201
TS203-A
TS203-B
BFQ12
TS201 BC 107
TS 202 BC 107
TS 204 BF W11
TS401 BCY56
C401 TBA 221B
IC 301 U917/1013/92
"ZERO"
V-R
I
0
SK2
DC-R
AC
$\mathrm{III_R}$
$\mathrm{IV_F}$
$\mathrm{III_F}$
$\mathrm{IV_R}$
$\mathrm{II_R}$
$\mathrm{II_F}$


1 — 99 MISCELLANEOUS
101 — 199 INPUT CIRCUIT
201 — 299 1x / 10x AMPLIFIER
301 — 399 AC / DC CONVERTER
401 — 499 Ohm CONVERTER
501 — 599 COMPARATOR , ANALOG TO DIGITAL CONVERTER LOGIC
601 — 699 "+"AND"-"REFERENCE
701 — 799 COUNTER / REGISTER + DISPLAY
801 — 899 POWER SUPPLY
= TEST POINT ON WIRING SIDE OF THE BOARD
= TEST POINT ON COMPONENT SIDE OF THE BOARD
= SOLDERED JUMPER ON COMPONENT SIDE OF THE BOARD
OVERRANGE DETECTOR
COMPARATOR
DECIMAL POINT
"OFFSET"
"CLOCKOSC CORR."
ANALOG / DIGITAL CONVERTER
IC 502
FEY 101 B/ S
"+CAL"
"ZERO CORR"
"OFFSET CORR"
"+" and "-" REFERENCE
200 Ω
2 kΩ
20 kΩ
200 kΩ
2 MΩ
20 MΩ
2 A
200 mA
20 mA
2 mA
200 µA
200 mV
2 V
20 V
200 V
1000 V
600 V AC
I_R
I_F

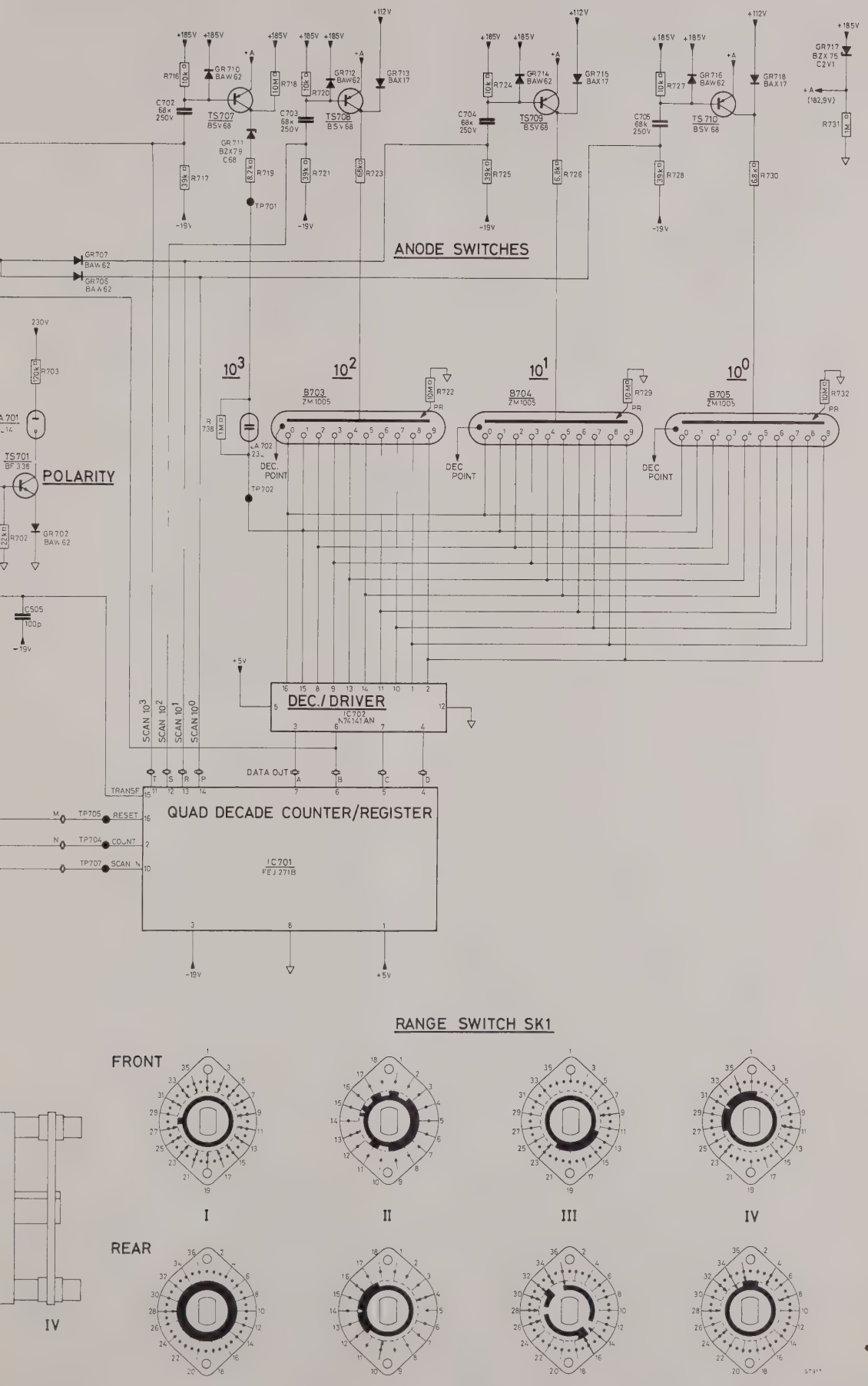


Fig. 36. Circuit diagram analog and digital section PM 2422 A

QUALITY REPORTING

CODING SYSTEM FOR FAILURE DESCRIPTION

The following information is meant for Philips service workshops only and serves as a guide for exact reporting of service repairs and maintenance routines on the workshop charts.
For full details reference is made to Information G1 (Introduction) and Information Cd 689 (Specific information for Test and Measuring Instruments).

LOCATION

□□□
Unit number
e.g. 000A or 0001 (for unit A or 1; not 00UA or 00U1)

or: Type number of an accessory (only if delivered with the equipment)
e.g. 9051 or 9532 (for PM 9051 or PM 9532)

or: Unknown/Not applicable
0000

CATEGORY

□
0 Unknown, not applicable (fault not present, intermittent or disappeared)
1 Software error
2 Readjustment
3 Electrical repair (wiring, solder joint, etc.)
4 Mechanical repair (polishing, filing, remachining, etc.)
5 Replacement
6 Cleaning and/or lubrication
7 Operator error
8 Missing items (on pre-sale test)
9 Environmental requirements are not met

COMPONENT/SEQUENCE NUMBER

□□□□
Enter the identification as used in the circuit diagram, e.g.:

GR1003	Diode GR1003
TS0023	Transistor TS23
IC0101	Integrated circuit IC101
R0....	Resistor, potentiometer
C0....	Capacitor, variable capacitor
B0....	Tube, valve
LA....	Lamp
VL...	Fuse
SK....	Switch
BU....	Connector, socket, terminal
T0....	Transformer
L0....	Coil
X0....	Crystal
CB....	Circuit block
RE....	Relay
ME....	Meter, indicator
BA....	Battery
TR....	Chopper

Parts not identified in the circuit diagram:

990000	Unknown/Not applicable
990001	Cabinet or rack (text plate, emblem, grip, rail, graticule, etc.)
990002	Knob (incl. dial knob, cap, etc.)
990003	Probe (only if attached to instrument)
990004	Leads and associated plugs
990005	Holder (valve, transistor, fuse, board, etc.)
990006	Complete unit (p.w. board, h.t. unit, etc.)
990007	Accessory (only those without type number)
990008	Documentation (manual, supplement, etc.)
990009	Foreign object
990099	Miscellaneous

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